THE PHILIPPINE JOURNAL OF SCIENCE

VOLUME 37

SEPTEMBER TO DECEMBER, 1928

WITH 57 PLATES AND 15 TEXT FIGURES

MANILA
BUREAU OF PRINTING
1928

238746

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[Issued October 25, 1928.]

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 37 SEPTEMBER, 1928 NO. 1

ABACÁ-SOIL CONDITIONS IN TWO DISTRICTS OF THE PHILIPPINE ISLANDS AND THEIR RELATION TO FIBER PRODUCTION *

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TWO PLATES

INTRODUCTION

The investigations and the experiments outlined in this paper were made with the object of throwing light on what probably has been and undoubtedly will continue to be the most serious trouble connected with abacá-fiber production; namely, weak fiber.

To gather the information and the material necessary for the prosecution of the work many months were spent in the abacá districts, more especially in those of the Bicol provinces of Camarines Norte, Camarines Sur, Albay, and Sorsogon, Luzon, and in Davao Province, southeastern Mindanao. In these places large collections were made from the growing plants, of the fibers considered representative.

These districts were especially chosen as furnishing the best examples of the oldest and the newest varieties of abacá plants, as well as the finest and the weakest. The methods of production, preparation, and storage, used probably seventy-five years ago, were studied side by side with those introduced during the past two or three years.

* The soil and ash analyses reported were made by the division of soils, Bureau of Science, Manila.

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The author would like to express personal thanks for all the help, coöperation, and good will he has received since beginning this work, but he feels that they would fall far short of the mark and that all of the space should be devoted to bringing out the evident satisfaction of the entire abacá industry at the inauguration of this pioneer work by the Cordage Institute of the United States. This is the more remarkable when it is understood that these investigations were made possible only through the active coöperation of Filipinos, Germans, Chinese, Spaniards, Britishers, and Americans engaged in the abacá industry, all of whom, without exception, did all they could to further the work. In the Bureau of Science and the Bureau of Agriculture, as well as in the Fiber Standardization Board, the chiefs and assistants of the various departments appealed to gave willing personal aid and assistance and undertook much of the detail work appearing here and yet to be published.

It is fundamental that plant growth is determined by the kind and the amount of the chemical substances furnished through its roots and by the surrounding conditions of moisture and climate. Serious disturbance of normal growth may result, consequently, from any change of normal conditions. This disturbance is generally manifested by disease or abnormal products, and in the case of abacá apparently by diminished resistance to disease and a weak fiber of short durability, in place of the strong, lasting fiber known all over the world as the premier cordage material.

Analyses of abacá disclose two distinct kinds of chemical constituents: inorganic, or the mineral salts taken from soil moisture by the roots; organic, or the material furnished both by the roots and by the photosynthesis of the plant itself in the leaves. These two kinds of chemical constituents combine to make the complex chemical bodies that supply the materials for plant growth and development.

MINERAL CONSTITUENTS OF ABACÁ FIBER

In order to understand better what the abacá plant has taken from the soil in the way of mineral substances necessary for its growth, ashes were made from characteristic varieties of abacá in various localities, and these ashes were analyzed for the principal mineral constituents recognized as being most important in plant growth. In preparing these ashes it was early discovered that their tendency to assume various colors during the burning of the fiber made it necessary to adopt a method

that would secure uniform results. This was especially necessary in as much as many persons have claimed a true distinction between abacá and Canton could be based solely on the differences between the color and the texture of the ashes of the respective fibers.

PREPARATION OF ABACÁ ASH

Twenty-five grams of the full length of fiber of each sample were taken, cut into small pieces, and charred in a large porcelain crucible, which was refilled about three times to complete the process. The heat was then increased (a muffle furnace was used) until the carbonaceous residue ignited and slowly burned out. The heat was again increased to low red, and the residual ashes oxidized to a permanent form without melting. After having been cooled in a desiccator and weighed, the ashes were transferred to a dry specimen tube, which was then sealed, and water-color paintings made of the ashes, as the photographs themselves could not be correctly colored.

After many experiments, it was proven that differences in amount, texture, color, and composition of the ash contents of a fiber were influenced by at least the following factors: Locality where grown; variety of abacá; maturity of the plant; grade of fiber. Other factors will be considered later. From these modifying conditions, especially the fourth one, it follows that a sample of ash is truly representative in all respects only of the fiber from which it is made, but is not representative even of the entire plant nor of that variety of abacá. The colored drawings, made from the ash specimens as mentioned above, illustrate some of the differences and similarities that appeared interesting and of possible future utility.

ASHES OF REPRESENTATIVE ABACÁ FIBERS OF THE BICOL PROVINCES

Sample 5 (Table 1) was a composite sample made up of equal parts of five varieties of abacá growing in the Bacacay district of Albay. Cleaning grade, Good to Fair.

Sample 6 (Table 1) was a composite sample made up of equal parts of five varieties of abacá, one variety selected from each of the following districts: Jovellar, Guinobatan, Manito, Bulan, and Tinapian. Cleaning grade, Good to Fair.

Samples 30, 31, 32, and 33 were taken from four representative varieties of abacá growing in the same field, Buhi district, Camarines Sur. Cleaning grade, Coarse.

TABLE 1.—*Chemical analyses of ashes of abacá-fiber samples from Bicol provinces.*

Sample No.	Silica (SiO_2).	Iron and aluminum oxides (R_2O_3).	Calcium oxide (CaO).	Magnesium oxide (MgO).	Potassium oxide (K_2O).	Sulphuric anhydride (SO_3).	Chloride (Cl).	Manganese oxide (MnO_2).	Phosphoric anhydride (P_2O_5).
	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
5	14.06	6.30	9.19	5.43	34.65	1.00	6.08	0.14	2.01
6	9.89	6.80	8.23	3.06	42.52	0.91	5.51	2.01	1.81
30	13.00	8.70	6.48	3.39	44.66	....	......	1.04	2.11
31	14.55	7.20	7.51	1.84	46.28	....	....	1.08	1.52
32	9.75	7.30	8.19	2.71	41.63	....	....	1.37	1.16
33	12.65	4.10	7.51	1.33	49.81			1.00	2.02

From the figures in Table 1 it is apparent that the principal and outstanding food constituents of abacá, other than nitrogen, coming from the soil are potash, iron, alumina, lime, magnesia, and silica. Silica, recognized as a hardening and protecting material rather than as one concerned with the vital processes of growth and development, may be disregarded in the present discussion. Iron and alumina will be discussed later and attention will be given more particularly first to potash and to lime with its associated magnesia.

To prove that the last-named three salts merit attention, not only because of their food qualities, but also on account of the quantities involved, it should be remembered that conservative figures for abacá-fiber production in the Philippines during many years is 1,250,000 bales per year, or a gross weight of 154,000,000 kilograms. Analyses of eighty fiber samples show an average ash content of 1.85 per cent by weight of the fiber, the samples mentioned in Table 2 having been analyzed.

TABLE 2.—*Ash content of eighty samples of abacá fiber.*

Number of samples.	Locality.	Grade of cleaning.	Ash. Average weight.	Ash. Per cent.
			g.	
27	Bicol area	Excellent	0.23	0.92
31	do	Good and fair	0.49	1.96
22	do	Coarse	0.67	2.68
Average			0.46	1.85

Taking 1.85 per cent as representing the ash content of the commercial fiber harvested, at least 1.5 per cent should be added to represent the ash from the immense amount of waste fiber and pulp discarded by the stripping knives, almost all of which is also lost to the soil. We have therefore, conservatively, over 3 per cent, or about 5,000,000 kilograms of mineral constituents in the yearly abacá crop, of which over half is composed of potash and lime salts alone. That these areas have continued to produce for fifty years and are still producing, suffering as they have been an annual loss of nearly 5,000 tons of mineral constituents essential to abacá production, seems almost impossible and, while it must make us marvel at their past fertility, it certainly also should make us fearful for the future. Not that the situation cannot be met and handled, but that up to the present neither preliminary nor experimental work has been undertaken by the Government or by private interests to demonstrate the best way of doing in a wholesale way that which obviously must be done—the reconditioning of the abacá fields. Unless such experimental work is started at once and prosecuted with vigor the task will become increasingly difficult each year.

To call attention again to the true significance of these figures, a brief description of the methods of abacá-fiber production and preparation must be given, the essential features of which are the cutting down of the entire plant; the selection from it of some 15 per cent of the outer sheaths; and the stripping of these layers under an especially arranged knife blade to produce the commercial fiber, which constitutes a little less than 2 per cent by weight of the entire plant cut down. In as much as the process of harvesting the fiber by present methods removes only about 10 or 15 per cent of the material of the entire crop, the other 85 to 90 per cent is allowed to remain on the ground, and thus become plant food again through the agency of fermentation and decay. The products of fermentation are acid in character and, when dissolved by the rains and absorbed by the soil, not only are made available as plant food but also aid materially in dissolving the soil minerals, thus changing them from potential into available food products. This cycle of changes, then, is repeated at least twice a year throughout the abacá fields. Millions of kilograms of plants are cut down but only a small part removed; the rest are left, to return to the soil through fermentation and decay and be reabsorbed by the

remaining uncut, growing plants. This process of harvesting is certainly unique and probably peculiar to abacá. That the soil is enriched and fertilized by the immense amount of organic and inorganic material spread over it semiannually is undoubtedly true and is shown by the very high percentages of humus found almost without exception in all the abacá soil analyses. It also perhaps accounts for the fact that the abacá planter, from earliest time to the present, has been content to take his semiannual crop of fiber and do nothing, absolutely nothing, in the way of plowing, cultivation, fertilization, or crop rotation, to return to the soil that which has been taken away as fiber, amounting to millions of kilograms annually.

Deeper digging into the present conditions of our abacá soils reveals several facts. The first is that the tremendous quantities of fermenting plant material left on the ground around the growing plants for months at a time form large quantities of acid products which are absorbed by the soil, making it acid or sour. This excess acidity reacts in various ways, most of which are harmful unless promptly dealt with. Some of the acid is directly absorbed by the growing abacá plants, the pernicious effects of which absorption will be described later; some of it leaches out through heavy rainfalls and disappears in the surface or subsoil run-off; much of it reacts chemically with the soil minerals, becoming neutralized and forming salts that in turn may be absorbed by the plants. The mineral that apparently acts as the great neutralizer of these acids of fermentation and decay is limestone, and in making soil analyses it has been found most convenient to measure the soil acidity in terms of lime equivalents. It is, therefore, a prime necessity for soils, where large quantities of acids are periodically spread over them, to have sufficient lime available not only to neutralize the acidity as it appears, but also to supply the heavy and constant needs of the growing crop. The roots of the plants penetrate but a relatively short distance into the surrounding soil; the movement of soil moisture is, in general, slow in heavy soils, so that it would seem advisable to apply lime or change the soil through plowing and cultivation. The Philippine planter has never changed his soil by plowing. It is, therefore, high time to examine the actual chemical condition of the soils of the large areas that have been producing abacá crops on an average of twice a year for a half century or more with practically no plowing, cultivation, or crop rotation.

The samples of surface soils, the chemical and physical analyses of which are given in Tables 3 and 4, were collected from the principal abacá districts of the Bicol provinces of Camarines Norte, Camarines Sur, Albay, and Sorsogon, at the same time and in the same locality as the fiber samples were taken from the various commercial varieties of abacá plants producing there. Care was taken to secure as representative samples of soils as possible, and the samples were invariably taken from spots equally distant from the surrounding hills of abacá; in other words, the effort was made to obtain the most favorable sample, and as far removed from local root proximity as possible. While the fields from which some of the samples were taken are comparatively young (say, ten to fifteen years under continuous crop production), most of them have probably been under crop for many years, it being no uncommon thing to find fields known to have been producing for forty to fifty years. As no study has yet been reported of soils and soil conditions in the abacá districts, and no standards of comparison were available, the only way to show the effects of abacá crops on soil was to compare old districts with new. For this reason the Davao district of Mindanao was chosen for comparison with the Bicol district, as the former is one of the newest, its fiber production per hectare several times that of the Bicol district, and its fiber the most uniformly strong and durable.

MECHANICAL ANALYSES OF ABACÁ SOILS OF THE BICOL PROVINCES

The mechanical analyses of soils here reported were made by the Schöne method as practiced by Osborne and as modified by Cox,[1] and the chemical analyses by the methods prescribed by the Association of Official Agricultural Chemists. To get their value and to understand their significance in the present instance, the following explanatory remarks may be permitted:

The roots of a growing plant are influenced to a very marked degree by the physical conditions of the soil surrounding them, for dependent on these conditions is the availability of the mineral foods, water, and air necessary for their growth. The prevailing opinion has been that abacá will grow well and produce heavily only in soils of sandy loam or even a coarser class, and these soils predominate in the Bicol district planted to abacá; yet, all the recent experience of planters in the Davao

[1] Philip. Journ. Sci. § A 6 (1911) 316.

district shows that, other conditions being favorable, even the clay and clay-loam types will produce heavy crops.

TABLE 3.—*Mechanical analyses of soils in the Bicol provinces, Luzon.*

[Water-free basis. Numbers indicate percentages.]

Serial No.	Classification.	Detritus not passing 1-mm. sieve.	(1) Coarse sand, 1 0.5 mm.	(2) Medium sand, 0 5–0 25 mm.	(3) Fine sand, 0.25–0 10 mm.	(4) Very fine sand, 0.10–0 05 mm.	(5) Silt, 0.05–0.005 mm.	(6) Clay, 0.003 mm.	Total, Nos. 1 to 6.
18	Sandy loam		11.6	23.9	25.2	14.1	19.3	5.9	100
34	do		7.6	20.0	30.4	11.2	26.9	3.9	100
40	Clay loam		1.2	3.4	12.9	12.5	48.8	21.2	100
71	Silt loam		1.1	5.8	21.0	13.6	50.2	8.3	100
72	Fine sandy loam		1.5	9.8	39.8	17.8	23.9	7.2	100
73	Sandy clay		2.5	12.7	31.3	10.0	26.7	13.8	100
74	do		1.7	10.6	23.9	11.8	31.3	11.7	100
92	Sandy loam		6.2	22.4	25.3	15.6	20.8	9.7	100
93	do		15.2	21.2	20.9	10.4	22.8	9.5	100
123	Sand	40.3	39.1	35.3	6.1	5.1	9.7	4.7	100
124	Sand loam	29.5	11.7	25.8	26.3	10.3	22.5	3.4	100
129	Fine sandy loam		1.5	8.4	41.4	17.1	29.4	2.2	100
138	Sandy loam	10.9	8.6	30.6	29.9	7.2	18.5	5.2	100
164	Fine sand		7.6	11.6	27.3	34.2	15.3	4.0	100
171	Sandy clay		6.7	12.9	25.6	20.5	28.7	5.6	100
185	Sand	39.2	43.2	32.8	8.7	4.0	9.4	1.9	100
186	Clay loam		11.0	10.6	10.2	9.5	38.0	20.7	100
193	Silty loam		1.0	5.6	24.3	7.8	48.7	12.6	100
200	Fine sandy loam		0.2	0.6	19.1	32.9	42.0	5.2	100
	Average		9.4	16.0	23.8	11.2	28.2	8.4	100

TABLE 4.—*Mechanical analyses of soils, Davao Province, Mindanao.*

[Water-free basis. Numbers indicate percentages.]

Serial No.	Abacá district.	Classification.	Detritus not passing 1-mm. sieve.	Coarse sand, 1–0.5 mm.	Medium sand, 0 5 0.25 mm.	Fine sand, 0.25–0.10mm.
501	Taguia	Clay loam	None	1.8	6.9	22.7
502	Bago	Loam	do	0.1	3.6	24.1
503	Patada	Silt loam	do	0.2	0.3	12.7
504	Daliao	Fine sandy loam	do	2.1	15.6	41.3
505	Bankas	Clay	do	0.2	3.0	15.4
506	Guianga	Silt loam	do	0.3	5.6	22.8
507	do	Sandy clay	do	2.6	7.0	30.0
508	Lais	do	do	2.7	13.3	24.7
509	Malita	Fine sandy loam	do	0.7	10.7	40.5
511	Kumasie	do	do	0.2	5.8	37.3
	Average			1.09	7.18	27.45

TABLE 4.—*Mechanical analyses of soils, etc.*—Continued.

Serial No.	Abacá district.	Classification.	Detritus not passing 1-mm. sieve.	Very fine sand, 0.10–0.05mm.	Silt, 0.05–0.005 mm.	Clay, 0.005 mm.	Total.
501	Taguia	Clay loam	None	8.3	37.2	23.1	100
502	Bago	Loam	do	9.7	44.7	17.8	100
503	Patada	Silt loam	do	25.0	53.7	8.1	100
504	Daliao	Fine sandy loam	do	15.4	14.3	8.3	100
505	Bankas	Clay	do	9.8	26.0	45.6	100
506	Guianga	Silt loam	do	10.7	51.4	9.2	100
507	do	Sandy clay	do	15.6	36.2	8.6	100
508	Lais	do	do	17.0	36.3	6.0	100
509	Malita	Fine sandy loam	do	19.7	18.4	10.0	100
511	Kumaie	do	do	17.5	32.6	6.6	100
	Average			14.87	35.08	14.33	100

The general results shown by the analyses presented in Tables 3 and 4 would also seem to substantiate the assertion that abacá can grow and produce well on soils of the heaviest as well as of the lightest type, provided only the chemical conditions are favorable and the proper variety of abacá is selected, the later being a very important consideration.

Taking for granted, then, until more evidence to the contrary has been presented, that there are suitable varieties of abacá for the many kinds of soils found in the districts of the Islands where climatic conditions are favorable for their growth, the chemical composition and conditions of these soils become of primary importance and merit the closest study.

The principal constituents of abacá ashes have been stated before and the order of their importance according to weight percentages is potash, silica, lime and magnesia, iron and alumina. Potash, comprising nearly half of the ash contents, is probably the most important mineral constituent necessary to abacá growth and development. Silica, being present always in excess in almost all soils, need not be considered here. Closely following silica, with an average of 10 per cent and more, are lime and magnesia, considered together on account of the similarity of their action. They are of special importance to the abacá planter and exporter for the reason that the more research given to the subject of the chemical constitution of the binding material of bast and pseudo-bast fibers [2] the more are

[2] Matthews, J. Merritt, Distinction of Bast and Pseudo Bast Fibers; Textile Fibers 3d ed (1916) 159, 170, 171.

chemists agreed that it is composed of a form of pectin in combination with lime and magnesia.[3]

This brings us to the question of abacá's fundamental requisite, the chemical substances necessary for making the strongest possible binding material for its fiber; for, no matter how well it may otherwise grow and thrive, if it produces weak fiber it is a failure from the commercial standpoint, and is degraded to the Canton class and called "bastard" fiber.

As has been stated before, we have no direct method of showing by chemical analysis whether the soils contain in sufficent quantities the essential substances needed by the plants for producing strong fibers, and neither the Government nor private interests appear to have established any standards for comparison. We are forced, therefore, to judge abacá soils by the standards worked out for other Philippine crops on which work has been done. Therefore, the ratings given in Tables 5 and 6 for the percentages of the various chemicals the soils contain, even though rather broad interpretation be given them and allowance made for possible special needs of abacá, are certain to give valuable information to those vitality interested. There is also a fundamental rule that appears applicable to most agricultural soils—that in order to avoid the detrimental effect of abnormal acid soil conditions plenty of lime and magnesia must be present to neutralize the acidity. A study of the analyses, especially of the soils in which the acidity is more than normal, as is true in the majority of cases in the Bicol district, indicates that the lime and magnesia rating is also low, while in the Davao district this is the case only where the crop is of many years' standing and, according to Davao practice, ready to be uprooted and replanted after a year of crop rotation.

The percentages of potash are so uniformly low in the Bicol district that it can be asserted with positiveness that there is serious disturbance to both the normal and even the present abacá growth, which must be far from normal. Even the much newer Davao soils, with careful plowing and cultivation, already show poor potash conditions in several districts. Phosphates, an essential plant food though used in comparatively small quantities and generally present in most Philippine soils, are also low in several Bicol districts. If these collected soil

[3] Matthews, J. Merritt, Composition of Binding Material; Textile Fibers, 387, 388. Ehrlich, F., Chem. Ztg. 41 (1917) 197-200. Abstracted in Chem. Abs. 11: 2898.

samples are at all representative (and they were collected with that end in view), the only conclusion we can get from their analyses and from the abacá-plant requirements as shown by their ashes is that the older abacá-soil areas, of which the Bicol area is an example, are decidedly lacking in potash and, as a general rule, also in the antiacid constituents, lime and magnesia.

The Davao soils, on the contrary, due perhaps to their relatively few years under crop and also to the constant plowing, cultivation, and often plant rotation to which they have been subjected, still compare very favorably, with few exceptions, with the standards laid down for fertile, well-balanced soils. It was found practically impossible to secure exact data regarding the number of years during which the various fields, from which the soil samples were taken, in the Bicol area, had been producing abacá crops. With few exceptions probably most of the fields have been producing for twenty years or longer; that some have been producing for over fifty years could be authenticated.

Where two samples of soils were collected from the same district, the effort was always made to secure them from widely separated localities or from localities the soil characteristics and topography of which were very different. In the Manito district sample 40 was taken from the west, No. 193 from the east side of the peninsula. In the Juban district both samples were from very old plantations, No. 73 from rolling to hilly land and No. 74 from a field located near Cadacan River. Sample 123 came from the south side of the Ligao-Tabaco Road, in the Bantayan district, and No. 124 was taken on the north side well up on the rolling hillsides, not far from Mount Masaraga. The Bacacay district is separated by the Malilipot-Libog Road into two distinct sections topographically. Sample 164 was secured well up on the side hills of Mayon Volcano, and No. 171 came from one of the old plantations near the town of Bacacay, where the land is flat and the soil very different from that of the hillsides above.

It was pointed out above that the abacá plant needs an abundant supply of lime to counteract undue soil acidity and to furnish the necessary supply of lime used by the plant, as one of the essential constituents of the binding material of the cells to form both individual fiber elements and also to bind these elements together into fiber bundles. Attention was also called to the fact that the soil samples collected in the older fields were gen-

TABLE 5.—*Chemical analyses of soils of the Bicol provinces of Camarines Norte, Camarines Sur, Albay, and Sorsogon.*[a]

Serial No.	Abacá district.	Topography.	Nitrogen (N_2).	Rating.	Phosphoric anhydride (P_2O_5).	Rating.	Lime (CaO).	Rating.	Magnesia (MgO).	Rating.
18	Daet, Camarines Norte	Flat	0.847	P	0.229	G	0.980	L	0.27	vL
34	Buhi, Camarines Sur	Rolling	0.313	P	0.232	G	0.72	L	0.85	L
40	Manito, Albay	Hilly	0.150	G	0.124	F	0.25	L	0.45	L
71	Sorsogon, Sorsogon	Flat	0.265	P	0.096	L	0.84	L	0.97	L
72	Irosin, Sorsogon	Hilly	0.337	P	0.225	G	1.08	L	0.58	L
73	Juban, Sorsogon	do	0.240	P	0.215	G	0.78	L	0.80	L
74	do	Rolling	0.335	P	0.254	G	0.37	vL	0.60	L
92	Joveilar, Albay	Hilly	0.120	G	0.066	L	0.82	L	0.59	L
93	Guinobatan, Albay	Sloping	0.326	P	0.225	G	3.83	G	0.99	L
123	Bantayan, Albay	Rolling	0.260	G	0.135	F	3.93	G	1.15	L
124	do	Hilly	0.065	L	0.186	F	2.46	G	1.17	L
129	Goa, Camarines Sur	do	0.546	P	0.400	G	1.19	L	0.73	L
138	Tiwi, Albay	Flat	0.313	P	0.222	G	2.64	F	1.28	L
164	Bacacay, Albay	Hilly	0.141	G	0.193	F	4.30	G	0.95	L
171	do	Flat	0.264	P	0.132	F	4.24	G	0.65	L
185	Ligao, Albay	Hilly	0.351	P	0.112	F	4.32	G	0.97	L
186	Putiao, Sorsogon	Flat	0.239	P	0.088	L	0.50	L	0.32	vL
193	Manito, Albay	Rolling	0.334	P	0.325	G	0.18	vL	0.17	vL
200	Bulan, Sorsogon	Flat	0.166	G	0.074	L	0.46	vL	0.22	vL

Serial No.	Abacá district.	Topography.	Potash (K_2O).	Rating.	Humus.	Rating.	Acidity as calcium carbonate ($CaCO_3$).	Rating.	Manganese (MnO_2).	Rating.
18	Daet, Camarines Norte	Flat	0.17	L	5.27	P				
34	Buhi, Camarines Sur	Rolling	0.19	L	6.82	P	0.009	s a		F
40	Manito, Albay	Hilly	0.08	v L	3.43	G	0.012	f a	0.05	G
71	Sorsogon, Sorsogon	Flat	0.19	L	2.80	G	0.012	f a	0.10	G
72	Irosin, Sorsogon	Hilly	0.07	v L	5.98	P	0.015	f a	0.02	L
73	Juban, Sorsogon	do.	0.21	L	4.20	P	0.012	f a	0.12	G
74	do.	Rolling	0.19	L	3.79	G	0.032	a	0.11	G
92	Jovellar, Albay	Hilly	0.20	L	1.91	F	0.012	f a	0.06	F
93	Guinobatan, Albay	Sloping	0.30	F	2.98	G	0.008	s a	0.03	L
123	Bantayan, Albay	Rolling	0.12	v L	2.57	G	0.009	s a	0.02	L
124	do.	Hilly	0.12	v L	2.20	G			0.05	F
129	Goa, Camarines Sur	do.	0.20	L	6.98	P				
138	Tiwi, Albay	Flat	0.12	v L	5.38	P	0.002	n	0.04	F
164	Bacacay, Albay	Hilly	0.13	v L	3.48	G			0.03	L
171	do.	Flat	0.22	L	2.41	G			0.02	L
185	Ligao, Albay	Hilly	0.13	v L	3.06	v L			0.06	F
186	Putiao, Sorsogon	Flat	0.23	L	1.12	F			0.35	P
193	Manito, Albay	Rolling	0.17	v L	2.41	G			0.37	P
200	Bulan, Sorsogon	Flat	0.13	v L	0.89	L			0.12	G

[a] The figures represent percentages, based on water-free samples. The percentages were obtained through digesting the soil with strong hydrochloric acid. Key to acidity rating: f a, fairly acid; s a, slightly acid; n, neutral. Key to rating of mineral contents of soils as compared with standard Philippine agricultural soils: F, Fair; G, Good; L, Low; v L, very Low; P, Plenty.

TABLE 6.—*Chemical analyses of soils of Davao Province.*[a]

Serial No.	Abacá district.	Topography and years under abacá crop.	Nitrogen (N_2).	Rating.	Phosphoric anhydride (P_2O_5).	Rating.	Lime (CaO).	Rating.	Magnesia (MgO).	Rating.
501	Taguia	Flat; 13 years	0.326	P	0.149	F	0.65	L	....	....
502	Bago	Sloping; 20 years	0.189	G	0.145	F	0.47	v L	....	....
503	Patada	Flat; 19 years	0.157	G	0.200	G	3.34	G	....	....
504	Daliao	Flat; many	0.128	G	0.247	G	0.18	v L	....	....
505	Bankas	Sloping; few	0.228	P	0.346	P	4.87	P	....	....
506	Guianga	Flat; few	0.336	P	0.238	G	0.72	L	....	....
507	do	Sloping; old	0.262	P	0.134	F	0.74	L	....	....
508	Lais	Sloping; 15 years	0.189	G	0.254	G	3.65	G	....	....
509	Malita	Flat; 13 years	0.132	G	0.219	G	2.18	G	....	....
511	Kumasie	Sloping; 15 years	0.145	G	0.127	F	3.63	G	....	....

Serial No.	Abacá district.	Topography and years under abacá crop.	Potash (K_2O).	Rating.	Humus.	Rating.	Acidity as calcium carbonate ($CaCo_3$).	Rating.	Manganese (MnO_2)	Rating.
501	Taguia	Flat; 13 years	0.29	L	1.96	F	0.010	s a	0.36	G
502	Bago	Sloping; 20 years	0.37	F	1.62	F	0.006	s a	0.41	G
503	Patada	Flat; 19 years	0.96	P	0.70	L	0.002	n	0.13	F
504	Daliao	Flat; many	0.13	v L	0.95	L	0.012	f a	0.12	F
505	Bankas	Sloping; few	0.32	F	1.84	F	Alk.	alk.	0.15	F
506	Guianga	Flat; few	0.26	L	1.93	F	0.006	s a	0.22	F
507	do.	Sloping; old	0.12	v L	1.67	F	0.005	n	0.15	F
508	Lais	Sloping; 15 years	0.58	G	0.79	L	0.004	n	0.08	L
509	Malita	Flat; 13 years	0.63	G	0.85	L	0.005	n	0.55	G
511	Kumasie	Sloping; 15 years	0.56	G	0.59	L	0.001	n	0.54	G

[a] The figures above represent percentages, based on water-free samples. The percentages were obtaned through digestihg the soil with strong hydrochloric acid. Key to acidity rating: f a, fairly acid; s a, slightly acid; n, neutral. Key to rating of mineral contents of soils as compared with standard Philippine agricultural soils: F, Fair; G, Good; L, Low; v L, very Low; P, Plenty.

erally found abnormally acid in reaction, despite the fact that precautions were taken to collect the samples where no fermenting waste was present. Where fiber harvesting has been going on and the ground is covered with a layer of fermenting abacá waste the acid conditions must be acute, and the dissolving action of the rains would take these acid solutions directly to the abacá roots before they could be neutralized by the small quantities of lime and magnesia generally present. In such case the acids would be absorbed by the roots, and taken up and distributed as such, or in some modified form, to various parts of the plant, including the fibers. It has long been recognized by fiber chemists that all acids, except the very weakest, have a weakening and deleterious effect on the binding substance of all fibers of the class that includes abacá. If these two assertions are correct then we should find an excess of acidity in the fibers coming from acid soils, and their tensile strength would also be less than that of fibers from normal soils. Experiments to show the average acidity and tensile strength of the collected fibers of the Bicol provinces compared with those of the Davao district were carried out as follows:

All fibers used in these experiments were dried quickly to prevent growth of molds and bacteria. The tensile strength, or breaking point, of the fibers was determined by testing accurately weighed fiber bundles exactly a half meter long in a Louis Schopper fiber-testing machine and measuring their breaking point in kilograms. In this way the tensile strength in kilograms per gram per meter of fiber was accurately determined; from ten to twenty tests on each sample of fiber were made and the average was taken.

The acidity of each sample of fibers was determined by using the same fiber that had been broken in the tensile-strength tests and adding to it enough fiber from the same abacá sample to make the weight 10 grams. These were cut into half-inch pieces, put in a 750 cubic centimeter round-bottomed flask, and heated on a water bath one hour with 500 cubic centimeters of distilled water, under frequent shaking. At the end of the hour as much of the solution as possible was poured off into an Erlenmeyer flask and the solution titrated with 0.1 *N* sodium hydroxide (NaOH), using phenolphthalein as indicator and titrating to a faint pink color on shaking. Many modifications were tried to make the experiment more accurate; but, as relative rather than absolute total amounts of free and soluble acids were desired, the figures given in Table 7 are correct

within 0.1 or 0.2 cubic centimeter, and are those found by the described method, and indicate the cubic centimeter of 0.1 *N* sodium hydroxide (NaOH) used to neutralize 10 grams of fiber. It is to be noted that the average acidity for six samples of fiber, collected on one plantation where the abacá was grown between rows of large coco trees and where the soil was found to be acid and deficient in both lime and potash, was over 1 cubic centimeter. Were these six not counted the average acidity for the Davao area would be 0.57 cubic centimeter instead of 0.64 cubic centimeter. Were a selection made of the samples of fiber grown only on acid soils low in lime, potash, and phosphates and their figures compared with those of fibers from normal soils the differences would be more marked, but even as given the differences in both tensile strength and acidity are sufficient to indicate a serious disturbance to normal abacá growth in poor soil and to give a working hypothesis as to its cause.

TABLE 7.—*Samples of fiber.*

Number of fiber samples tested.	Locality.	Average tensile strength.	Average acidity in cc. 0.1 *N* calcium carbonate (NaOH).
		kg.	
66	Four Bicol provinces	48.65	1.08
37	Davao	59.40	0.64

CHEMICAL CHARACTERISTICS OF WEAK FIBER [4]

There is also another phase to this excess soil acidity and lack of mineral foods that merits serious consideration. The analyses of various abacá ashes, given elsewhere in this paper, show the high average alumina content of from 5 to 7 per cent. It has been shown by plant pathologists that an excess of alumina in plant tissues indicates an unhealthy condition of the plant, so that the substitution of alumina for other minerals, such as lime or potash, becomes a question of necessity and not one of choice. In the study and comparison of weak and strong fibers it was also noticed early that strong fiber was characterized by its resistance to the dissolving or disintegrating action of hot water, in comparison with weak fiber, which has a relatively high percentage of water-soluble substance.

[4] Weak in the sense that the fiber came from a weak-fibered variety of abacá, but not weakened through fermentation or mold action.

CHEMICAL DIFFERENCES BETWEEN STRONG AND WEAK FIBERS

DIFFERENCES IN ASH COMPOSITION

Two samples of fiber from neighboring localities were selected, each of Good to Fair cleaning, No. 765 coming from a weak variety of abacá and No. 779 from a strong, standard fiber. Fifteen grams of each were carefully weighed, cut into short pieces, and incinerated at a low heat in a muffle furnace, as previously described. When the ashes had assumed a permanent color they were removed from the furnace, cooled in a desiccator, and weighed. The weights and chemical analyses are given in Table 8.

TABLE 8.—*Weights and chemical analyses of ash from two samples of abacá.*

No.	Ash.		Chemical analysis.		
	Weight.	Color.	Silica (SiO_2).	Alumina (Al_2O_3).	Lime (CaO).
	Per cent.		*Per cent.*	*Per cent.*	*Per cent.*
765	0.4105 or 2.7	Buff brown; powdery	28.03	9.47	10.66
779	0.4315 or 2.9	Deep gray; granular	16.15	4.46	12.35

DIFFERENCES IN ORGANIC MATTER SOLUBLE IN WATER

One hundred grams of each fiber were cut into fine pieces, and extracted with 1,000 cubic centimeters of warm distilled water for twenty-four hours. The extract was filtered off from each and used for the following determinations:

Acidity.—An aliquot part of each extract was titrated with 0.1 *N* sodium hydroxide ($NaOH$) to a faint pink color with phenolphthalein an indicator. Total acidity for 10 grams of fiber, measured in terms of 0.1 *N* sodium hydroxide ($NaOH$), was 3 cubic centimeters for No. 765 and 2 cubic centimeters for No. 779.

Neutral and basic lead acetate precipitates.—It was found that, by means of a mixture of neutral and basic lead acetate, water-soluble constituents of abacá fibers could be precipitated, washed, and thus purified for further study. Aliquot parts of the two extracts were accordingly precipitated with a slight excess of a mixture of neutral and basic lead acetate solution and the light-colored voluminous precipitates filtered and then washed until the wash water was free from lead acetate. The precipitates were then suspended in distilled water, the lead precipitated by hydrogen sulphide as lead sulphide and filtered off, and washed

with distilled water until the filtrate was no longer acid to litmus. The united filtrates were then evaporated, first on the water bath and later in a vacuum desiccator to constant weight and weighed.

	No. 765.	No. 779.
Weight of residue, grams	1.4938	0.5082
Residue, per cent	1.76	0.60

Qualitative examinations of the hot-water extracts of strong and weak fibers have so far shown them to consist of varying quantities of higher organic and presumably fatty acids, both free and combined as salts with alumina, lime, iron, and potash. In the residue from weak fibers aluminum was found to predominate largely over the other bases, while in the residue from strong fiber calcium and potash were in excess.

SUMMARY

For the most part, present conditions in the abacá areas of the Islands are of long standing rather than new or novel. We are thus reaping the results of the omissions and commissions of the abacá growers for the past fifty years, and these have been brought into prominence on account of the scientific developments of most of the other branches of the industry, after fiber has been produced.

The production of abacá fiber is unique by the fact that the soil is made to produce the same crop for an indefinite period without either plowing or cultivation being practiced (except in one district) or fertilization attempted beyond the addition to the soil of large quantities of abacá waste left to ferment in the fields after the fiber harvest.

The results of this practice are: On the soil, a steady and heavy exhaustion of the necessary plant-food minerals and a consequent permanent acid condition; on the plant, a lack of essential mineral salts on which the plant depends for proper growth and development and for the maintenance of normal resistance to disease. This is indicated by the low average yield per hectare of the older abacá districts; on the fiber, both an excess acidity that always produces short durability and an enforced substitution of necessary salts by inferior ones resulting in a loss of tensile strength.

The benefits of the modern practices of abacá production in the Davao district are shown by the relatively better condition of the soil, the increased yield of fiber per hectare, and the uniformly high quality of the fiber.

ILLUSTRATIONS

PLATE 1

FIGS. 81 to 89. Upper row. Ashes from the fiber of eight varieties of abacá; Good to Fair cleaning, growing in the Masarauag section of the Guinobatan district, Albay Province, Luzon. Showing somewhat close conformity of colors and amounts with one another.

2 to 10. First section of lower row. Ashes from the fiber of varieties of abacá furnishing the commercial fiber from the Daet district, Camarines Norte, Luzon; all fiber cleaned to Excellent grade. No. 2, variety Antiguo, mature; No. 3, variety Samoro, mature; and No. 10, variety Alinsanay, mature, were growing in the same field within short distances of each other. To show the effect of age on the color of the ash compare No. 3, Samoro mature, with No. 4, Samoro immature, and No. 7, Samoro overmature. Number 2 and No. 8 are both Antiguo mature, but from different localities; Nos. 3 and 9 are Samoro mature, but from different localities.

30 to 33. Ashes from the fiber of four varieties of abacá growing together in the Buhi district, Camarines Sur, Luzon; named, respectively, Samokid, Samorong itom, Samorong pula, and Salampago; cleaning grade, Coarse.

PLATE 2

FIGS. 95 to 104. Ashes from fiber of four varieties of abacá, Fair to Coarse cleaning, from another section of the Guinobatan district, Albay.

108 and 113. Ashes from fiber of two varieties of abacá, Amokid and Itom, Fair to Coarse cleaning; from the Bantayan district, Albay, south of the Ligao-Tabaco Road.

117 and 121. Ashes from two varieties of abacá, Amokid and Puti, Fair to Coarse cleaning; from the northern end of the Bantayan district, Albay.

125 and 168. Ashes from fibers of two varieties of abacá from the Goa-Lagonoy district, Camarines Sur; fiber of No. 168, Coarse cleaning.

135 to 168. Ashes from fibers of abacá from the Tiwi-Horovan district, Albay; Fair to Coarse cleaning.

176 to 180. Ashes from fibers of three varieties of abacá from the Putiao district, Albay; Fair to Coarse cleaning.

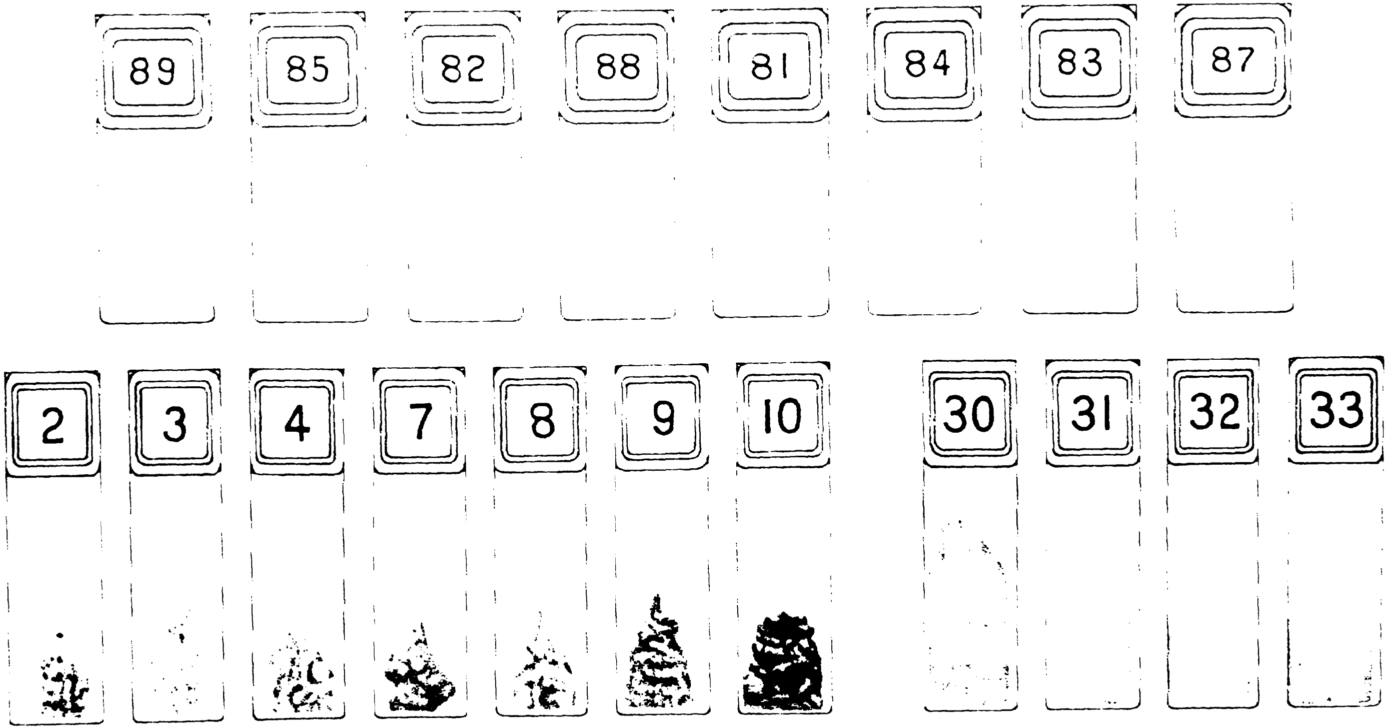

PLATE 1

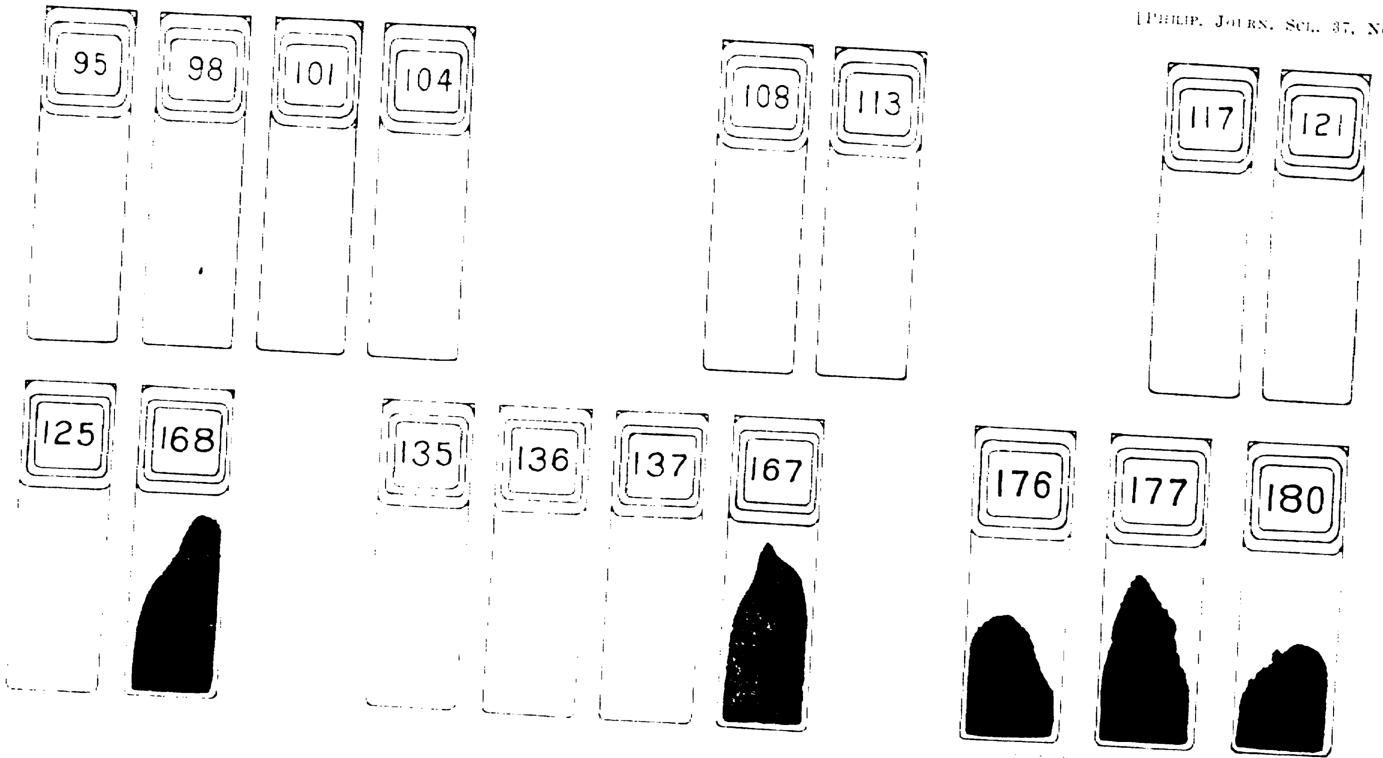

PLATE 2.

THE TENSILE STRENGTH OF ABACÁ FIBERS IN RELATION TO THEIR ACIDITY

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IN COLLABORATION WITH

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It is not generally known that there are certain organic acids that occur naturally in abacá fibers. No work that we have been able to locate has been reported in the scientific literature dealing with these acids.

This paper is a report of the experiments performed at the Bureau of Science, Manila, in the attempt to discover: (1) What relationship exists between the tensile strength of a sample of abacá fiber and the amount of acid present; (2) whether there is any mathematical connection between speed and amount of loss of tensile strength of an abacá-fiber sample during storage and its acid content.

RELATIONSHIP BETWEEN TENSILE STRENGTH AND ACID CONTENT

In order to determine how much variation in moisture exists when abacá fibers of various cleaning grades are subjected to the fluctuations in humidity found in the laboratory, five samples of different grades of cleaning were taken from the abacá storage room, where they had been hanging for months, put in a desiccator and immediately weighed. The abacá storage room is a closed dark room that contains several large open pans of anhydrous calcium chloride. The calcium chloride is renewed each week. This storage room was prepared in the manner described, not with the intention of keeping the abacá samples bone dry, but merely with the expectation of avoiding any excess of moisture in the fibers during storage.

The five samples of abacá used in this experiment, after being weighed, were placed in Petri dishes in a laboratory where the windows were left open day and night. The samples were left exposed for seventeen days, and were weighed once or twice

TABLE 1.—*Weight in grams of abacá samples in an open laboratory, November, 1927.*

Grade of cleaning.	Nov. 10.	Nov. 11.	Nov. 12.	Nov. 14.	Nov. 15[a]	Nov. 16[a]	Nov. 17.	Nov. 18.	Nov. 19[a]	Nov. 21.	Nov. 22.	Nov. 23.	Nov. 25.	Nov. 26.
WEIGHTS TAKEN AT 8 A. M.														
C				5.3355	5.3392	5.3842	5.4295	5.3816	5.4303	5.4300	5.4232	5.4050	5.3578	5.3299
F				3.0100	3.0127	3.0693	3.1068	3.0592	3.1042	3.0985	3.0878	3.0772	3.0336	3.0011
J_2				5.4682	5.4713	5.5100	5.5600	5.5122	5.5629	5.5557	5.5477	5.5345	5.4992	5.4736
L				6.1250	6.1275	6.1895	6.2415	6.1806	6.2398	6.2369	6.2239	6.2075	6.1550	6.1200
DM				3.1872	3.1866	3.2177	3.2357	3.2112	3.2354	3.2354	3.2285	3.2200	3.1996	3.1888
WEIGHTS TAKEN AT 3 P. M.														
C	5.3412	5.3464	5.2708	5.3182	5.3912	5.4285	5.3928	5.3966	5.4857	5.4126	5.3832	5.3131	5.3095	5.3339
F	3.0122	3.0242	2.9582	2.9921	3.0512	3.1110	3.0765	3.0650	3.1519	3.0840	3.0549	2.9927	2.9879	3.0057
J_2	5.4613	5.4750	5.4000	5.4522	5.5245	5.5665	5.5141	5.5251	5.6122	5.5342	5.5108	5.4438	5.4387	5.4655
L	6.1200	6.1366	6.0457	6.1050	6.1942	6.2490	6.1900	6.1973	6.3480	6.2150	6.1820	6.1000	6.0913	6.1205
DM	3.1838	3.1915	3.1522	3.1800	3.2200	3.2418	3.2065	3.2185	3.2529	3.2239	3.2113	3.1850	3.1708	3.1862

[a] Rain.

a day to ascertain the changes in moisture content. Table 1 shows the fluctuations in weight.

After seventeen days the samples were put in an electric drying oven at 105° C., and dried to constant weight. Calculations made on the weights obtained show that the percentage of moisture in the samples varied according to the figures given in Table 2.

TABLE 2.—*Percentage of moisture in abacá samples.*

Grade.	Moisture in abacá in dark, partially dry storage room.	In open laboratory. Least moisture in abacá.	Most moisture in abacá.	Moisture in abacá on the last day of exposure.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
C	9.40	8.28	11.87	9.36
F	12.40	10.84	16.52	12.22
J_2	9.84	8.81	12.26	9.91
L	10.15	9.05	13.38	10.16
DM	9.40	8.52	11.35	9.50

The results indicated prove that there is only a relatively small variation in the percentage of moisture present in abacá samples exposed to the air for seventeen days. The difference in percentage between the minimum and the maximum water content was only around 3 per cent, except in the case of the fiber of grade F. A careful examination of Table 1 shows that the fluctuations in water content are slow and gradual changes, and that the maximum water content of the fibers occurred only after thirty hours of continuous rain. We were unable to obtain a moisture-conditioning room which would have ensured a definite and exact control of the water content of the abacá samples. We adopted, for all of the experiments described in this paper, the method used by the Fiber Standardization Board of the Philippine Islands, and we believe it gave only a small percentage of error. The following method was the one employed:

All abacá samples were kept in the dark semidry room previously described, until ready for use. The sample selected for experimentation was exposed in the laboratory for only six hours, if the day was rainy, and for twenty-four hours under ordinary weather conditions. Drawing our conclusions from the figures in Table 1, we believe the variation in moisture content of the samples used did not exceed 1 per cent, and the consistent and uniform results obtained seem to confirm this belief.

In order to determine what difference in tensile strength might be expected with a variation of moisture content of 1 per cent, the following experiment was devised:

Forty bundles of fibers were selected from the same sample, and prepared for tensile-strength determinations according to methods adopted by the Fiber Standardization Board. Twenty fiber bundles were placed over an open dish of water, without being allowed to come in contact with it, and left for twelve hours. The tensile strength was determined on ten of the fibers by the method described later, and the moisture content was determined on the remaining ten fibers. The tensile strength was 53.87 kilograms, calculated on the basis of the breaking force required on a gram of fiber weight, which was a meter in length, and the average moisture content was 9.9 per cent.

The remaining twenty fiber bundles were put in an electric drying oven at 103° C. for two hours. Half of these fibers were used for tensile-strength determinations, and the other half for moisture determinations. The average tensile strength was 58.08 kilograms per gram of fiber weight per meter of length. The average moisture content of these fibers was 0.89 per cent. There was a change of 4.19 kilograms in tensile strength for 9.08 per cent loss of moisture, or about 0.45 kilogram change in tensile strength for 1 per cent of moisture.

The figures for tensile strength and percentage of elasticity given in this report were determined in a 50-kilogram Louis Schopper tensile-strength machine. The figures given for each sample are the average of from ten to twenty determinations made on each sample. The fibers for the separate determinations were selected from different parts of the sample, according to a definite method, adopted by the Fiber Standardization Board as giving uniform results. The tensile-strength numbers in the tables of this report are the average of at least ten determinations and were obtained by calculation from the actual figures obtained in the Louis Schopper machine, and they represent the number of kilograms necessary to break fiber weighing 1 gram and measuring a meter in length.

The elasticity numbers show the average percentage of stretch, when fiber bundles 20 centimeters long were used.

The acidity numbers were determined in the following way: Approximately 10 grams of abacá fiber were selected from different parts of the sample, and exactly 10 grams were weighed out. The weighed sample was cut finely, placed in an Erlenmeyer flask with 500 cubic centimeters of distilled water, and

heated one hour on the steam bath. The liquid was poured from the fiber, and the total acid content of the decanted liquid and washings was determined by titration with 0.1 *N* sodium hydroxide (NaOH), using phenolphthalein as indicator. Additional tests made on the fiber residue proved that very little acid remained. We are using these acid figures, however, as indicating the relative acid content of the abacá samples examined, rather than the total acidity.

After making many determinations, we noticed a striking relationship between the tensile strength and elasticity, and the relative acid content of a given abacá sample. As the tensile strength and elasticity decrease, the relative acid content increases.

While we would not attempt at this stage of the investigation to state that the acidity of an abacá sample is a determining or causative factor of its tensile strength, our tables show a surprisingly uniform parallelism between the tensile strengths and the relative acid content.

In order to make our comparisons more easily seen, we have classified all the samples into three groups; namely, the samples with tensile strengths of from 50 to 59 kilograms, inclusive; the samples with tensile strengths of 40 to 49 kilograms, inclusive, and the samples with tensile strengths below 40 kilograms.

There were too few samples with tensile strengths above 60 kilograms to make a fair basis of comparison, so these figures were not included.

Eighty-two abacá samples (Table 3) showed an average tensile strength of 54.87 kilograms; an average percentage of elasticity of 2.50; and an average acidity of 0.89 cubic centimeter in terms of 0.1 *N* sodium hydroxide (NaOH).

Seventy-eight abacá samples (Table 4) showed an average tensile strength of 44.0 kilograms; an average percentage of elasticity of 2.37; and an average acidity in terms of 0.1 *N* sodium hydroxide (NaOH) of 1.31 cubic centimeters.

Thirty-three abacá samples (Table 5) showed an average tensile strength of 35.45 kilograms; an average percentage of elasticity of 2.11; and an average acidity in terms of 0.1 *N* sodium hydroxide (NaOH) of 1.73 cubic centimeters.

For an average decrease in tensile strength of approximately 10 kilograms, there is also a decrease in percentage of elasticity of from 0.13 to 0.26; and an increase of acidity of 0.42 cubic centimeters in terms of 0.1 *N* sodium hydroxide (NaOH).

TABLE 3.—*Fiber samples having tensile strength of 50 to 59 kilograms, with their corresponding acidity.*

No.	Origin.	Variety.	Tensile strength.	Elasticity.	Acidity in terms of 0.1 *N* NaOH.
			kg.	*Per cent.*	*cc.*
525	Libbey, Davao	Lauan	56.9	2.56	0.58
526	do.	Tangonong	54.5	2.60	0.62
527	do.	Libuton	50.7	2.37	0.58
528	do.	Maguindanao	57.4	2.65	0.60
530	Bago, Davao	Tangonang	56.4	2.52	0.70
531	do.	Libuton	50.9	2.36	0.60
532	do.	Maguindanao	56.6	2.75	0.50
533	do.	Bungalanon	58.6	2.40	0.50
538	Patada, Davao	do.	58.1	2.32	0.50
539	do.	Tangongon	56.5	2.22	0.49
540	do.	Maguindanao	55.8	2.77	0.55
541	do.	Libuton	56.0	2.21	0.60
542	do.	Lauanan	57.0	2.66	0.50
550	Daliao, Davao	Maguindanao	56.0	2.52	0.30
551	do.	Tangongon	56.2	2.48	0.30
552	do.	Bungalanon	56.5	2.24	0.30
553	do.	Maguindanao	54.3	2.81	0.50
554	do.	Tangongon	53.6	2.49	0.76
555	do.	Bungalanon	58.2	2.47	0.80
573	Malita, Davao	Abacá	59.8	2.23	0.70
574	do.	do.	57.8	2.20	0.80
596	Jolo, Jolo Island	Lanut agutay	57.7	2.13	0.90
753	Ligao, Albay	Abacá	50.5	2.37	0.60
756	Libog, Albay	Taguiltil	56.6	2.88	1.30
757	do.	Bungoranon.	58.3	2.63	0.60
758	do.	do.	56.1	2.35	1.10
760	Pandan, Albay.	Amokid	51.0	2.58	0.30
761	do.	Abacá	59.0	2.43	0.60
762	do.	Amokid	59.0	2.55	0.30
763	do.	Abacá	55.4	3.00	0.40
780	Tabaco, Albay	Samorong itom	53.0	2.79	0.60
781	do.	do.	55.7	2.66	0.30
785	do.	Canton	56.1	2.35	0.40
794	Bacacay, Albay	Samorong puti.	53.6	2.60	1.20
800	Libog, Albay	Samorong itom	53.7	2.64	0.40
801	do.	do.	54.8	2.64	0.40
805	do.	Canton	58.7	2.35	0.60
808	do.	do.	50.7	2.30	1.10
809	do.	do.	53.3	2.60	0.50
804		do.	52.9	2.46	0.60
812	Bacon, Sorsogon	Samorong itom	52.1	2.86	0.70
814	Gubat, Sorsogon	do.	52.0	2.86	0.50
815	do.	do.	51.4	2.86	0.40
820	Rapurapu, Albay.	Abacá	51.2	2.44	2.10
832	Ligao, Albay	do.	53.3	2.50	1.20
840A	Casiguran, Sorsogon	do.	54.8	2.37	1.20
840B	do.	do.	59.5	2.62	1.20

TABLE 3.—*Fiber samples having tensile strength of 50 to 59 kilograms, with their corresponding acidity*—Continued.

No.	Origin.	Variety.	Tensile strength.	Elasticity.	Acidity in terms of 0.1 N NaOH.
			kg.	*Per cent.*	*cc.*
202	Daet, Camarines Norte	Antiguo	57.4	2.60	5.50
203	do	Samoro	57.4	2.71	4.50
204	do	do	59.4	2.65	0.60
210	do	Alinsanay	55.2	2.57	0.80
213	do	do	58.1	2.28	0.55
214	do	do	57.2	2.52	0.45
222	Ligao, Albay	Kidit	59.4	2.49	0.30
224	do	Samoro	59.8	2.36	0.50
235	Tinapian, Albay	Buranom puti	55.1	2.92	0.95
244	Sorsogon, Sorsogon	Pulá	57.2	2.67	1.00
250	Juban, Sorsogon	Lagonoy	51.9	2.40	0.90
251	do	do	56.2	2.40	0.40
253	do	Puti	53.0	2.45	0.90
254	do	do	50.9	2.58	1.00
256	do	Lagonoy	50.7	2.31	0.90
260	do	Samoro puti	55.8	2.26	0.60
262	do	Binagacay	52.7	2.26	0.60
263	do	Lagnis	50.6	2.10	0.60
264	do	Samoro pulá	57.8	2.40	0.30
266	Patad, Sorsogon	Isarog	59.3	2.70	1.00
270	do	Pulá	54.8	2.61	0.70
283	Masaraw, Albay	Rayado	50.2	2.49	2.10
288	do	Amoraon	50.4	2.34	1.60
295	Guinobatan Experiment Station, Albay.	Puti	53.9	2.38	0.60
296	do	do	56.0	2.47	1.00
298	do	Itom	53.6	2.58	1.60
299	do	do	53.7	2.62	1.50
301	do	Bagacayon	51.1	2.56	1.00
302	do	do	52.0	2.80	1.20
309	Tabaco, Albay	Puti	50.0	2.99	1.70
313	Bantayan, Albay	Itom	50.8	2.53	1.20
327	Goa, Camarines Sur	do	59.7	2.42	0.60
332	Bacacay, Albay	Binohuran	56.9	2.48	0.90
341	Tabaco, Albay	Abacá	51.8	2.47	1.00
347	do	do	52.3	2.67	1.00
379	Putiao, Sorsogon	puti	52.4	2.82	1.20
380	do	Samoro puti	53.2	2.00	1.00
381	do	do	50.2	2.08	0.90
397	Bulan, Sorsogon	Abacá	54.4	1.99	0.60
399	do	do	50.4	2.06	1.50
	Total abacá fibers		4,499.4	205.52	73.33
	Average abacá fibers		54.87	2.50	0.89
	Total Canton fibers		271.7	12.06	3.20
	Average Canton fibers		54.3	2.40	0.64

TABLE 4.—*Fiber samples having tensile strength of 40 to 49 kilograms, with their corresponding acidity.*

No.	Origin.	Variety.	Tensile strength.	Elasticity.	Acidity in terms of 0.1 *N* sodium hydroxide (NaOH).
			kg.	*Per cent.*	*cc.*
741	Rapurapu, Albay	Canton J_2	45.6	2.42	1.50
743	do	Canton I	45.9	2.39	0.90
745	do	Canton M_1	41.6	2.28	1.20
748	do	Canton G	44.9	2.26	1.20
750	Ligao, Albay	Abacá	47.2	2.38	0.30
751	do	do	44.3	2.41	0.70
752	do	do	47.7	2.77	0.70
759	Sorsogon, Sorsogon	Amokid	48.7	2.62	1.00
766	Libon, Albay	Samorong puti	48.2	2.50	1.90
767	do	do	45.3	2.51	2.00
768	do	Canton	42.9	2.23	2.30
796	Bacacay, Albay	Abacá	47.8	1.28	0.40
799	Libog, Albay	do	44.5	2.75	0.90
802	do	Canton puti	42.8	2.36	1.50
803	do	do	42.8	2.49	0.50
806	do	Canton pulá	40.9	2.16	2.00
807	do	do	45.9	2.46	0.70
810	Bacon, Sorsogon	do	48.4	2.79	0.70
811	do	do	48.4	2.67	1.40
813	do	Abacá	46.7	2.62	0.90
819	Legaspi, Albay	do	40.8	2.59	2.80
821	Donsol, Sorsogon	do	49.6	2.25	4.70
833	Kabankalan, Occidental Negros	Mixed	48.9	1.94	1.80
841 c	Casiguran, Sorsogon	Abacá	47.7	2.36	1.20
848	Southern Albay	Balones	43.8	2.28	3.80
201	Daet, Camarines Norte	Alinsanay	43.1	2.52	0.90
211	do	do	47.4	2.67	0.60
212	do	do	46.8	2.36	0.75
216	do	Abacá	47.8	2.64	0.60
230	Buhi, Camarines Sur	Samokid	41.5	2.53	1.20
232	do	Samorong pulá	40.4	2.24	1.70
233	do	Salampago	40.6	2.15	0.90
236	Tinapian, Albay	Buranom pulá	48.7	2.21	0.80
237	do	Bagcacayon puti	48.5	2.65	0.85
238	do	Samina itom	46.7	2.67	1.00
241	Sorsogon, Sorsogon	Puti	49.4	2.46	0.90
246	do	Amokid	40.5	2.31	1.20
248	Juban, Sorsogon	Agpas	42.8	2.78	1.60
252	do	Isarog	45.9	2.16	1.20
275	Jovillar, Albay	Samina	41.8	2.57	1.50
276	do	Samoro itom	47.9	2.32	1.20
277	do	Bagcacayon	40.6	2.78	1.30
278	do	Samoro puti	49.1	2.39	1.20
279	do	Cañaraon	41.4	2.62	1.30
281	Guinobatan, Albay	Puti	44.5	2.66	2.10
282	do	Amokiron	46.7	2.45	2.00
284	do	Binagacay	45.8	2.21	1.60
285	do	Itom	48.2	2.46	0.90

TABLE 4.—*Fiber samples having tensile strength of 40 to 49 kilograms, with their corresponding acidity*—Continued.

No.	Origin.	Variety.	Tensile strength.	Elasticity.	Acidity in terms of 0.1 *N* sodium hydroxide (NaOH).
			kg.	*Per cent.*	*cc.*
287	Guinobatan, Albay	Pulá	49.9	2.33	1.50
289	do	Burit	40.0	2.32	0.70
290	do	Abacá	45.9	2.44	1.10
291	do	do	45.6	2.32	1.40
297	Guinobatan Experiment Station, Albay.	Itom	49.4	2.45	1.60
300	do	Bagacayan	43.4	2.27	1.80
303	do	Tomatagacan	48.6	2.68	1.20
304	do	do	46.9	2.46	1.00
305	do	do	47.4	2.53	2.40
306	do	Abacá	42.2	2.15	1.40
307	do	do	44.8	2.16	0.80
308	Bantayan, Albay	Amokid	40.2	1.97	1.60
310	do	Pulá	43.1	2.09	1.00
311	do	Aggikikon	46.7	2.64	1.00
314	do	Itom	43.9	2.33	1.20
317	do	Amokid	46.6	2.27	0.90
318	do	Pulá	46.8	2.30	1.90
319	do	Agonoy	44.7	2.36	1.90
320	do	Itom	44.2	2.30	2.60
322	do	Aggikikon	45.8	2.40	1.20
333	Bacacay, Albay	Itom	40.0	2.62	1.30
335	Tiwi, Albay	do	49.6	2.18	2.00
336	do	Pulá	49.5	2.40	1.30
339	Tabaco, Albay	Abacá	47.2	2.38	0.90
340	do	do	49.5	2.42	1.00
342	do	do	49.6	2.51	1.00
343	do	do	40.0	2.08	1.30
353	Bacacay, Albay	Torotagácan	41.6	2.38	1.30
355	do	Bulao	41.0	2.26	0.90
361	do	Pulayog	40.5	2.24	1.00
362	do	Puti	44.9	2.43	0.90
363	do	Itom	41.9	2.34	1.20
366	do	Canton	43.8	1.94	1.80
374	Tabigian, Albay	Mindanao	45.7	2.42	1.50
375	do	Pulá	40.9	2.22	1.30
376	Putiao, Sorsogon	Samina	44.0	2.39	0.90
377	do	Samoro puti	49.7	2.47	0.80
378	do	Alaon	43.7	2.09	0.80
383	do	Amokid	47.4	2.20	1.00
392	Manito, Albay	Puti	41.3	1.83	1.60
767	Libon, Albay	Abacá	45.3	2.51	2.00
806	Libog, Albay	Canton pulá	40.9	2.16	2.00
798	do	Abacá	47.8	2.68	0.60
	Total, excluding Cantons		3,534.5	185.62	102.60
	Average abacá fibers		44.0	2.37	1.31
	Total, excluding abacás		574.8	30.61	17.70
	Average Canton fibers		44.2	2.35	1.43

TABLE 5.—*Fiber samples having tensile strength of below 40 kilograms with their corresponding acidity.*

No.	Origin.	Variety.	Tensile strength.	Elasticity.	Acidity in terms of 0.1 *N* sodium hydroxide (NaOH).
			kg.	*Per cent.*	*cc.*
727	Catanduanes, Albay	Canton mix	39.2	2.26	6.60
728	do	do	30.2	2.33	6.70
737	Rapurapu, Albay	Canton	21.4	1.13	1.10
738	do	do	24.5	2.21	3.10
739	do	do	29.7	2.01	2.60
740	do	do	30.9	1.92	2.10
744	do	do	27.8	2.09	1.50
746	do	do	33.4	1.18	1.30
747	do	do	36.6	2.13	1.30
749	Jolo	do	25.0	1.45	2.80
751	Ligao, Albay	Abacá	37.6	2.08	0.70
764	Pandan, Albay	do	34.6	2.44	2.00
769	Libon, Albay	Canton	38.8	2.11	3.00
770	Caholhon, Albay	Abacá	27.7	2.15	2.00
771	do	do	29.1	2.07	4.70
774	do	Canton itom	23.1	2.33	1.70
775	do	do	24.3	1.87	4.10
778	Tabaco, Albay	Samorong itom	39.0	2.40	0.90
779	do	do	29.4	2.06	0.90
782	do	Canton puti	29.5	2.14	2.00
783	do	do	23.6	1.86	5.30
786	Pandan, Albay	Amokid	28.0	2.63	0.70
787	do	do	26.1	2.01	1.70
788	Bacacay, Albay	Canton puti	27.4	1.90	6.00
789	do	do	35.7	3.50	0.80
791	do	Canton pulayog	27.1	1.79	6.30
795	do	Abacá	37.2	2.54	1.50
816A	Pandan, Albay	Mixed A and C	23.4	1.72	2.20
817	Southern Albay	Abacá	38.0	2.48	2.70
818	do	do	38.5	2.62	1.10
823	Negros	Balones	22.8	2.42	1.90
834	Rapurapu, Albay	Canton	39.4	2.14	1.80
842A	Goa, Camarines Sur	Abacá	39.6	1.93	4.20
844	Legaspi, Albay	do	38.4	1.06	1.00
845	Tabaco, Albay	do	37.9	2.15	4.10
846	do	Canton	28.0	1.80	4.30
847	Camarines Norte	do	11.9	1.87	6.30
849	do	do	33.8	2.03	5.20
850	do	do	28.1	1.60	5.80
228	Iriga, Camarines Sur	Abacá	31.2	1.88	2.10
231	Buhi, Camarines Sur	Samorong itom	37.2	2.15	1.20
239	Tinapian, Albay	Canton	30.4	1.70	1.20
247	Juban, Sorsogon	Agpas	35.9	2.05	1.20
294	Guinobatan, Albay	Puti	38.2	2.03	0.80
312	Bantayan, Albay	do	38.3	1.91	2.30
321	do	do	29.1	1.94	0.90

TABLE 5.—*Fiber samples having tensile strength of below 40 kilograms with their corresponding acidity*—Continued.

No.	Origin.	Variety.	Tensile strength.	Elasticity.	Acidity in terms of 0.1 *N* sodium hydroxide (NaOH).
			kg.	*Per cent.*	*cc.*
330	Bacacay, Albay	Canton pula	30.5	1.74	1.40
331	....do	Canton puti	26.8	1.37	1.70
337	Tiwi, Albay	Puti	36.5	2.33	1.70
348	Tabaco, Albay	....do	38.6	2.31	1.90
350	Bacacay, Albay	Itom	39.0	2.39	1.20
351	....do	Binanguran	36.3	2.22	0.90
352	....do	Puti	37.3	2.17	1.70
354	....do	Agonoy	37.5	2.52	1.10
356	....do	Moronganom	37.4	2.09	1.20
358	....do	Morong datu	26.5	1.86	1.10
359	....do	Pacol	20.2	2.21	2.60
360	....do	Abacá	24.9	1.84	1.20
367	Horoan, Albay	do	37.7	1.96	0.90
368	Caramoan Peninsula	do	36.0	1.94	4.00
369	Pandan, Albay	....do	31.2	2.31	1.20
382	Putiao, Sorsogon	Pacol	24.4	1.23	1.30
388	Manito, Albay	Canton puti	34.3	1.70	2.20
389	....do	Pulá	30.6	1.37	1.00
390	....do	Tipontipon	39.2	1.50	1.00
387	Guinobatan, Albay	Abacá	28.9	1.96	2.60
391	Manito, Albay	Puti	34.9	1.31	1.00
398	Bulan, Sorsogon	Canton	39.5	1.79	2.00
401	Rapurapu, Albay	do	26.1	1.37	1.50
408	Masaraw, Albay	Canton puti	31.2	2.09	2.00
409	....do	Abacá	38.1	2.01	1.10
395	Caramoan Peninsula, Camarines Sur.	Canton	22.8	1.42	3.30
	Total abacá fibers		1,170.4	69.83	57.30
	Average abacá fibers		35.45	2.11	1.73
	Total Canton fibers		932.7	59.96	92.00
	Average Canton fibers		30.0	1.87	2.96

THE RELATION BETWEEN TENSILE STRENGTH AND ACID CONTENT FOR CANTON FIBERS

Canton fibers are obtained from hybrid plants and are apparently crosses between abacá and banana.

The five Canton fiber samples that are included in Table 3 have an average tensile strength of 54.3 kilograms; an average percentage of elasticity of 2.40; and an average acidity in terms of 0.1 *N* sodium hydroxide (NaOH) of 0.64 cubic centimeters.

Thirteen Canton fiber samples (Table 4) show an average tensile strength of 44.2 kilograms; an average percentage of

elasticity of 2.35; and an acid content in terms of 0.1 *N* sodium hydroxide (NaOH) of 1.43 cubic centimeters.

Thirty-one Canton fiber samples (Table 5) show an average tensile strength of 30 kilograms; an average percentage of elasticity of 1.87; and an average acidity in terms of 0.1 *N* sodium hydroxide (NaOH) of 2.96 cubic centimeters.

In the case of Canton fibers there is also an increase of acid content as the tensile strength decreases, but it is not so uniform as in the case of abacá. Only a few Canton fibers are represented in Tables 3 and 4, so that these results are to be expected.

Nearly all Canton fibers have a tensile strength below 40 kilograms; they are included in this article because the average figures for Canton fibers as found in Table 5 are of value as supporting evidence in distinguishing between true abacá fibers and Canton fibers, in case of dispute in fiber identification.

The average figures for the Canton fiber samples (Table 5) are not in themselves to be taken as conclusive proof of identity, since some abacá samples show the same figures; but these numbers are often very useful in confirming other, more-important tests that have indicated that the fiber under investigation is probably a Canton fiber.

RATE OF LOSS OF TENSILE STRENGTH DURING STORAGE AND THE ACID CONTENT

An experiment was undertaken to show whether or not a mathematical relationship exists between the speed and the amount of loss of tensile strength in abacá fibers during storage and the acid content. The fibers used for this experiment were kept six months or longer in the dark, semidry storage room described above. The moisture content of the fibers in this room ranged from 9 to 11 per cent. The tensile strengths were determined twice on the same sample after an interval of storage of six months or longer. An acid determination was also made on the same sample usually at the end of the period of storage. Our results, doubtless, would have been more valuable had we made several acid determinations on each sample at intervals during the period of storage. At the beginning of this research work, however, we did not foresee the relationship between tensile strength and acidity. At present, we have no way of knowing whether the acid content of a given sample varied or not during the period of storage. It is conceivable that some of the fibers that showed the greatest loss of tensile strength

but which, at the time of titration, had a low acid content may have had a high quantity of acid at the beginning of storage. These acids may have dissolved, or chemically changed the binding material of the middle lamella of the abacá during storage, thus lowering the tensile strength of the fiber. During this process the acids themselves may have been used up, so that only a small amount of acid was left in the perished fiber.

It is also possible that deterioration of abacá may have been caused more by the nature of the acids present than by their quantity. Certain acids are formed during bacterial fermentation, and it is possible that small quantities of the acid products of fermentation may have a more deleterious effect on abacá than larger amounts of those organic acids that are normally present. We wish to emphasize, at this point, that the greater part of the samples tested were not commercial samples, but were gathered personally in the field, and were stripped and dried under conditions that would make fermentation impossible.

Drawing our conclusions from the data now at hand, we have not found that any regular mathematical relationship exists between the rate of loss of tensile strength during storage and the amount of acid present. In no case, however, did we find abacá with an unduly high acid content, but that the fiber either already had a low tensile strength, or else it showed a much lowered tensile strength after long storage.

SUMMARY

1. The natural acid content of abacá is greater in fibers having low tensile strengths.

2. As the tensile strengths of abacá samples decrease about 10 kilograms per gram of weight per meter of length, the natural acidity of the fiber increases about 0.42 cubic centimeter for each 10 grams. The acidity is measured in terms of 0.1 *N* sodium hydroxide (NaOH) using phenolphthalein as an indicator.

3. The natural acid content is also higher for Canton fibers with a low tensile strength, but the mathematical relationship between the tensile strength and the acid content is less definite for these hybrids than it is for true abacá.

4. Loss of tensile strength in abacá during storage is affected by the acid content, but as yet no definite mathematical relationship between the rate of loss of tensile strength and the acid content has been discovered.

TABLE 6.—*Showing changes of tensile strength during storage.*

No.	Origin.	Variety.	Tensile strength.	Elasticity.	Date.	Acidity in terms of 0.1 *N* sodium hydroxide (NaOH).	Date.
			kg.	*P. ct.*		*cc.*	
525	Libbey, Davao	Lauan	56.9	2.56	Oct. 27, 1926	0.58	Aug. 5, 1927.
525	do	do	53.9	2.09	Aug. 2, 1927		
528	do	Magindanao	57.4	2.65	Oct. 30, 1926	0.60	Aug. 5, 1927.
528	do	do	53.9	2.26	Aug. 4, 1927		
533	Bago, Davao	Bungalanon	58.6	2.40	Nov. 2, 1926	0.50	Aug. 8, 1927.
533	do	do	56.0	2.15	Aug. 9, 1927		
541	Patada, Davao	Libuton	56.0	2.21	Jan. 10, 1927	0.60	Aug. 15, 1927.
541	do	do	53.9	2.03	Aug. 12, 1927		
542	Bago, Davao	Lauan	57.0	2.66	Jan. 10, 1927	0.50	Aug. 15, 1927.
542	do	do	54.5	2.25	Aug. 15, 1927		
550	Daliao, Davao	Magindanao	56.0	2.52	Nov. 24, 1926	0.30	Aug. 18, 1927.
550	do	do	52.7	2.28	Aug. 17, 1927		
555	do	Bungalanon	58.2	2.47	Dec. 27, 1926	0.80	Sept. 9, 1927.
555	do	do	54.3	2.15	Sept. 8, 1927		
557	Kumasie, Davao	Magindanao	62.9	2.38	Sept. 10, 1927	1.20	Sept. 13, 1927.
557	do	do	59.4	2.11	Sept. 21, 1927		
564	do	Libuton	67.3	2.51	Jan. 25, 1927	1.00	Sept. 6, 1927.
564	do	do	63.1	1.89	Sept. 13, 1927		
565	Lais, Davao	Bungalanon	60.2	2.37	Jan. 26, 1927	0.50	Sept. 6, 1927.
565	do	do	57.7	1.90	Sept. 21, 1927		
567	Malita, Davao	Baguisanon	66.8	2.41	Feb. 3, 1927	0.50	Sept. 6, 1927.
567	do	do	62.0	1.94	Sept. 23, 1927		
569	do	Magindanao	64.2	2.63	Feb. 3, 1927	0.50	Sept. 6, 1927.
569	do	do	60.0	2.28	Sept. 23, 1927		
570	do	Bungalanon	65.9	2.46	Feb. 4, 1927	0.40	Sept. 6, 1927.

570	....do	.....do	62.2	2.01	Sept. 26, 1927		
571	.....do	Opuopus	68.5	2.45	Feb. 4, 1927	0.30	Sept. 6, 1927.
571	.....do	.....do	65.7	1.88	Sept. 26, 1927		
572	.....do	Tangongon	61.6	2.65	Feb. 4, 1927	0.50	Sept. 6, 1927.
572	.....do	.....do	58.8	2.04	Sept. 26, 1927		
575	.....do	Magindanao	60.4	2.17	Feb. 10, 1927	1.20	Sept. 6, 1927.
575	.....do	.....do	55.7	1.47	Sept. 26, 1927		
742	Rapurapu, Albay	Canton J	44.4	2.54	Dec. 4, 1926	0.90	Dec. 4, 1926.
742	.....do	.....do	41.3	2.43	Mar. 25, 1927		
743	.....do	Canton I	45.9	2.39	Dec. 4, 1926	0.90	Dec. 4, 1926.
743	.....do	.....do	42.5	2.33	Mar. 25, 1927		
748	.....do	Canton G	44.9	2.26	Dec. 4, 1926	1.20	Dec. 4, 1926.
748	.....do	.....do	41.9	2.32	Mar. 29, 1927		
766	Libon, Albay	Abacá samorong puti	48.2	2.50	Apr. 4, 1927	1.90	Oct. 28, 1927.
766	.....do	.....do	45.9	2.39	June 6, 1927		
771	Caholhon, South	Abacá	29.1	2.07	Apr. 6, 1927	4.70	Oct. 28, 1927.
771	Catanduanes		25.8	1.70	July 7, 1927		
791	Bacacay, Albay	Canton	27.1	1.79	Apr. 13, 1927	6.30	Nov. 1, 1927.
791	.....do	Pulayog	22.7	1.68	June 17, 1927		
817	Legaspi, Albay		38.0	2.48	Jan. 24, 1927	2.70	Jan. 24, 1927.
817	.....do		35.8	2.04	June 24, 1927		
840B	Casiguran, Sorsogon		59.5	2.62	Mar. 28, 1927	1.20	Mar. 28, 1927.
840B	.....do		57.4	2.73	Apr. 1, 1927		
236	Tinapian Albay	Bungaranon	48.7	2.24	Oct. 28, 1925	0.80	Mar. 28, 1927.
236	.....do	Pula	45.0	2.11	Aug. 30, 1927		
241	Sorsogon, Sorsogon	Puti	49.4	2.46	Oct. 30, 1925	0.90	Mar. 28, 1927.
241	.....do	.....do	46.3	1.81	Aug. 30, 1927		
253	Juban, Sorsogon	.....do	53.0	2.45	Nov. 4, 1925	0.90	Sept. 19, 1927.
253	.....do	.....do	50.6	2.06	Aug. 30, 1927		
266	Patad, Sorsogon	Isarog	59.3	2.70	Nov. 11, 1925	1.00	Sept. 19, 1927.
266	.....do	.....do	55.9	2.09	Aug. 30, 1927		

TABLE 6.—*Showing changes of tensile strength during storage*—Continued.

No.	Origin.	Variety.	Tensile strength.	Elasticity.	Date.	Acidity in terms of 0.1 N sodium hydroxide (NaOH).	Date.
			kg.	P. ct.		cc.	
282	Masaraw, Albay	Amokiron	46.7	2.45	Nov. 13, 1925	2.00	Sept. 19, 1927.
282	do	do	43.4	1.90	Aug. 31, 1927		
531	Bago, Davao		50.9	2.36	Nov. 1, 1926	0.60	Aug. 8, 1927.
531	do	do	48.5	2.09	Aug. 8, 1927		
245	Sorsogon, Sorsogon		62.2	2.46	Nov. 2, 1925	0.45	Aug. 8, 1927.
245	do		57.6	2.22	Aug. 30, 1927		
529	Bago, Davao	Lauan	60.6	2.64	Oct. 30, 1926	0.50	Aug. 8, 1927.
529	do	do	53.6	2.10	Aug. 6, 1927		
530	do	Tangonong	56.4	2.52	Nov. 1, 1926	0.70	Aug. 8, 1927.
530	do	do	47.6	2.17	Aug. 6, 1927		
543	Patada, Davao	Pulahan	61.6	2.48	Nov. 4, 1926	0.80	Aug. 15, 1927.
543	do	do	56.3	2.05	Aug. 15, 1927		
559	Kumasie, Davao	Putian	61.4	2.51	Jan. 15, 1927	0.50	Sept. 13, 1927.
559	do	do	56.3	2.48	Sept. 10, 1927		
560	do	Ponokan	60.4	2.52	Jan. 15, 1927	1.00	Sept. 6, 1927.
560	do	do	52.7	2.14	Sept. 12, 1927		
561	do	Baguisanon	60.3	2.28	Jan. 18, 1927	1.20	Sept. 13, 1927.
561	do	do	48.6	1.57	Sept. 2, 1927		
562	do	Tangongon	63.0	2.46	Jan. 22, 1927	1.40	Sept. 6, 1927.
562	do	do	51.1	1.87	Sept. 12, 1927		
563	do	Bungalanon	66.7	2.44	Jan. 22, 1927	1.10	Sept. 14, 1927.
563	do	do	60.3	1.92	Sept. 13, 1927		
568	Malita, Davao	Buntot	64.0	2.45	Feb. 3, 1927	0.60	Sept. 6, 1927.
568	do	do	56.8	1.73	Sept. 23, 1927		
597	Jolo	Lanut itom	75.7	2.94	Mar. 3, 1927	0.60	Sept. 6, 1927.
597	do	do	70.1	2.84	Sept. 27, 1927		

741	Rapurapu, Albay	Canton J	45.6	2.42	Mar. 25, 1926	1.50	Dec. 4, 1926.
741	do	do	40.5	2.19	June 4, 1927		
747	do	Canton K	36.6	2.13	Dec. 4, 1926	1.30	Dec. 4, 1926.
747	do	do	30.1	2.24	Mar. 27, 1927		
767	Libon, Albay	Abacá, samorong puti	45.3	2.51	Apr. 4, 1927	2.00	Oct. 28, 1927.
767	do	do	38.2	2.02	June 6, 1927		
769	do	Canton minay or samina	38.8	2.11	Apr. 4, 1927	3.00	Oct. 28, 1927.
769	do	do	33.5	1.81	June 6, 1927		
788	Bacacay, Albay	Canton	27.4	1.90	Apr. 12, 1927	6.00	Oct. 29, 1927.
788	do	Puti	20.5	1.51	June 17, 1927		
807	Libog, Albay	Canton pulá or itom-baba	45.9	2.16	Apr. 20, 1927	0.70	Nov. 1, 1927.
807	do	do	36.5	1.98	June 8, 1927		
840A	Casiguran, Sorsogon	Abacá	51.8	2.37	Mar. 28, 1927	1.20	Nov. 1, 1927.
840A	do	do	48.2	2.39	Apr. 29, 1927		
841C	do	do	47.7	2.56	Mar. 28, 1927	1.20	Nov. 1, 1927.
841C	do	do	36.5	2.05	Apr. 1, 1927		
237	Tinapian, Albay	Bagcacayon	48.5	2.65	Oct. 28, 1925	0.85	Nov. 1, 1927.
237	do	Puti	40.2	1.89	Aug. 30, 1927		
248	Juban, Sorsogon	Agpas with fruit	42.8	2.78	Nov. 2, 1925	1.60	Nov. 1, 1927.
248	do	do	33.7	1.71	Aug. 30, 1927		
252	do	Isarog	45.9	2.46	Nov. 4, 1925	1.20	Sept. 19, 1927.
252	do	do	33.2	1.66	Aug. 30, 1927		
260	do	Samoro puti	55.8	2.26	Nov. 6, 1925	0.60	Oct. 26, 1927.
260	do	Pananon	47.5	1.96	Aug. 30, 1927		
264	do	Puti	57.8	2.40	Nov. 6, 1925	0.30	Oct. 26, 1927.
264	do	do	45.7	1.78	Aug. 30, 1927		
276	Joveliar, Albay	Samorong	47.9	2.32	Nov. 13, 1925	1.20	Sept. 19, 1927.
276	do	Itom	23.9	1.39	Aug. 31, 1927		
277	do	Bagcacayon	40.6	2.78	Nov. 13, 1925	1.30	Sept. 19, 1927.
277	do	do	28.8	1.43	Aug. 31, 1927		
278	do	Samoro	49.1	2.39	Nov. 13, 1925	1.20	Sept. 19, 1927.
278	do	Puti	31.2	1.56	Aug. 31, 1927		

TABLE 6.—*Showing changes of tensile strength during storage*—Continued.

No.	Origin.	Variety.	Tensile strength.	Elasticity.	Date.	Acidity in terms of 0.1 N sodium hydroxide (NaOH).	Date.
			kg.	*P. ct.*		*cc.*	
283	Masaraw, Albay	Rayado	50.2	2.49	Nov. 13, 1925	2.10	Sept. 19, 1927.
283	do	do	43.3	2.10	Aug. 31, 1927		
526	Libbey, Davao	Tangonong	54.5	2.60	Oct. 27, 1926	0.62	Aug. 5, 1927.
526	do	do	53.3	2.07	Aug. 3, 1927		
540	Patada, Davao	Magindanao	55.8	2.77	Jan. 8, 1927	0.55	Aug. 15, 1927.
540	do	do	54.3	2.49	Aug. 12, 1927		
551	Daliao, Davao	Tangongon	56.2	2.48	Nov. 11, 1926	0.50	Aug. 19, 1927.
551	do	do	54.7	2.26	Aug. 18, 1927		
552	do	Bungalanon	56.5	2.24	Dec. 14, 1926	0.30	Aug. 22, 1927.
552	do	do	54.8	2.02	Aug. 22, 1927		
554	do	Tangongon	53.6	2.49	Dec. 24, 1926	0.76	Sept. 7, 1927.
554	do	do	52.3	2.43	Sept. 6, 1927		
573	Malita, Davao	do	59.8	2.23	Feb. 7, 1927	0.70	Sept. 7, 1927.
573	do	do	59.4	1.74	Sept. 26, 1927		
595	Jolo, Jolo	Lanut puti	60.2	2.69	Mar. 3, 1927	0.90	Sept. 6, 1927.
739	Rapurapu, Albay	Canton L_2	29.7	2.01	Dec. 4, 1927	2.60	Dec. 4, 1926.
739	do	do	28.4	2.00	May 23, 1927		
738	do	Canton DL	24.5	2.21	Dec. 4, 1926	3.10	Dec. 4, 1926.
738	do	do	23.8	1.86	May 23, 1927		
740	do	Canton L_1	30.9	1.92	Dec. 4, 1926	2.10	Dec. 4, 1926.
740	do	do	29.6	1.47	Mar. 23, 1927		
744	do	Canton M_2	27.8	2.09	Dec. 4, 1927	1.50	Dec. 4, 1926.
744	do	do	27.4	2.09	Mar. 25, 1927		
773	Caholhon, South	Abacá	60.2	2.64	Apr. 6, 1927	0.80	Oct. 28, 1927.
773	Catanduanes	Lupis	58.7	2.60	July 7, 1927		

779	Tabaco, Albay	Samorong	29.4	2.06	Apr. 8, 1927	0.90	Oct. 29, 1927.
779	do	Itom	27.7	1.90	June 9, 1927		
795	Bacacay, Albay	Abacá samorong puti	37.2	2.54	Apr. 16, 1927	1.50	Nov. 1, 1927.
795	do	do	36.3	2.09	May 11, 1927		
806	Libog, Albay	Canton	40.9	2.16	Apr. 20, 1927	2.00	Nov. 1, 1927.
806	do	Pulá or itom	39.2	2.00	June 18, 1927		
816A	Pandan, Albay	do	23.4	1.72	Apr. 22, 1927	2.20	Nov. 1, 1927.
816A	do	do	22.6	1.61	June 23, 1927		
235	Tinapian, Albay	Buranom	55.1	2.92	Oct. 27, 1927	0.95	Nov. 1, 1927.
235	do	Puti	53.5	2.53	Aug. 30, 1927		

TABLE 7.—*Loss of tensile strength during storage, with corresponding acidity of abacá samples.*

No.	Tensile strength lost during storage. Loss of from 1 to 1.90 kilograms.	0.1 *N* sodium hydroxide (NaOH) necessary to neutralize acids of 10 grams of abacá.	No.	Tensile strength lost during storage. Loss of from 2 to 4.90 kilograms.	0.1 *N* sodium hydroxide (NaOH) necessary to neutralize acids of 10 grams of abacá.	No.	Tensile strength lost during storage. Loss of 5 kilograms and above.	0.1 *N* sodium hydroxide (NaOH) necessary to neutralize acids of 10 grams of abacá.
	kg.	*cc.*		*kg.*	*cc.*		*kg.*	*cc.*
SAMPLES HAVING TENSILE STRENGTH OF 50 KILOGRAMS AND ABOVE.								
526	1.20	0.62	525	3.00	0.58	529	7.00	0.50
540	1.50	0.55	528	3.50	0.60	530	8.80	0.70
551	1.50	0.50	533	2.60	0.50	543	5.30	0.80
552	1.70	0.30	541	2.10	0.60	559	5.10	0.50
554	1.30	0.76	542	2.50	0.50	560	7.70	1.00
573	0.40	0.70	550	3.30	0.30	561	11.70	1.20
595	0.70	0.90	555	3.90	0.80	562	11.90	1.40
773	1.50	0.80	557	3.50	1.20	563	6.40	1.10
235	1.60	0.95	565	2.50	0.50	568	7.20	0.60
			253	2.40	0.90	597	5.60	0.60
			266	3.40	1.00	840A	6.60	1.20
			564	4.20	1.00	260	8.30	0.60
			567	4.80	0.50	264	12.10	0.30
			569	4.20	0.50	283	6.90	2.10
			570	3.70	0.40			
			571	2.80	0.30			
			575	4.70	1.20			
			245	4.60	0.45			
			572	2.80	0.50			
			840B	2.10	1.20			
			531	2.40	0.60			
Total	11.40	5.58		69.00	14.13		110.60	12.60
Average	1.26	0.62		3.23	0.673		7.82	0.87
SAMPLES HAVING TENSILE STRENGTH OF 40 TO 49 KILOGRAMS.								
			766	2.30	1.90	767	7.10	2.00
			236	3.70	0.80	811C	11.20	1.20
			241	3.10	0.90	237	8.30	0.85
			282	3.30	2.00	248	9.10	1.60
						252	12.70	1.20
						276	24.00	1.20
						277	11.80	1.30
						278	17.90	1.20
Total				12.40	5.60		102.10	10.55
Average				3.10	1.40		12.76	1.32
SAMPLES HAVING TENSILE STRENGTH OF BELOW 40 KILOGRAMS.								
779	1.70	0.90	771	3.30	4.70			
795	0.90	1.50	817	2.20	2.70			
816A	0.80	2.20						
Total	3.40	4.60		5.50	7.40			
Average	1.13	1.53		2.75	3.70			

FERMENTATION AS AFFECTING THE QUALITY OF PHILIPPINE ABACÁ

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ONE PLATE

INTRODUCTION

According to the nomenclature adopted by the United States Department of Agriculture "Philippine abacá" designates the fiber produced from the plant *Musa textilis* Née and differentiates it from the other twenty and more fibers known commercially as hemp, which are grown in various parts of the world. In as much as the fiber of *Musa textilis* is now produced in Borneo, Java, and Sumatra somewhat extensively the prefix "Philippine" designates the fiber produced only in the Philippine Islands.

The word "abacá" apparently first appears historically in Pigafetta's classic diary of Magellan's Trip Around the World in 1519. In giving a list of the native articles in common use and the words used for them as found on Cebu Island, he says: "For the cloth with which they cover themselves, abacá." This cloth, woven from abacá fiber, is still extensively woven and worn in the southern Philippines.

Abacá is indigenous to the Philippines. That it is endemic and that the production of the fiber has been a monopoly up to the present are certain. The million and more bales of commercial fiber annually exported from the Islands are produced from many varieties of this one species of *Musa* as well as from apparently other more or less closely allied species, whose relationship to the true abacá is yet to be determined.

As a result of business stagnation following the World War many thousand bales of abacá fiber were stored in Manila and provincial warehouses for periods varying from a few months

to more than two years. When this fiber was exported considerable quantities were found on arrival to be more or less deteriorated in both color and tensile strength, and consequently it brought into prominence as never before the problem of quality deterioration. Preliminary investigations of the commercial methods of fiber production and storage begun some three years ago indicated that most of the fiber deterioration started during the period of its production in the provinces and was augmented and completed afterwards by storage in warehouses and ships.

Investigations in the laboratory, following those made in the field, showed that this quality deterioration could often be measured chemically and that this measurement will give valuable information as to the kind and amount that has taken place even before it is evinced through lowering of tensile strength and while an acceptable color of the fiber is still present.

The causes and the results of fiber deterioration are many and varied; some are accidental, while others are fundamental defects of the present system of production, but among the latter not one has caused the damage that can be legitimately ascribed to the lack of systematic and complete drying of the freshly stripped fiber; and, in order that the work described below may be the better understood, the essential steps in the commercial production of abacá fiber and the far-reaching results following the same are here briefly recapitulated.

To secure the maximum amount of fiber with the minimum expenditure of labor and time, the outside layer only of each of the long, fleshy leaf stems (which overlapping, form the stalk, or trunk, of the abacá plant) is pulled off from the underlying pulpy portion. This outside fibrous layer, in strips of varying width and thickness and comprising some 15 per cent of the weight of the entire trunk, is known as "tuxie" and its removal is the first step in the production of the true fiber which appears when the tuxies are in turn passed under a stripping knife to remove pulp, juice, outside skin, and short, weak fiber. The completeness of this process of cleaning the fiber is determined by the kind of knife used as well as by the pressure exerted by it on the tuxie strip. If the knife blade is sharp and the pressure sufficient, only fiber of excellent cleaning results. Insufficient pressure or a knife blade that is either dull or even serrated permits the production of all other grades even to the coarsest strips.

The fresh fiber as it comes from the stripping knife is so saturated with plant juices that even hand pressure is suffi-

cient to expel them, and all of the chemical constituents that they contain consequently dry into the fiber during the drying process that follows. This drying process, as will be shown later, is of the utmost importance to the future strength and durability of the fiber, yet no drying sheds are ever provided, and the fiber being dried in the open is subjected to all the vicissitudes of a tropical wet climate and the drying consequently requires anywhere from two hours to two weeks.

The freshly stripped fiber is bright in luster, high in color, very elastic, and somewhat weak. Quick and thorough drying accomplishes the triple purpose of making permanent the luster; of keeping the color from darkening, except very slowly; and of hardening and toughening the fiber strands, together with the more or less pulpy substances surrounding them, and thereby reducing the elasticity to normal. The fiber, promptly and and well dried, is then in its best possible physical condition to perform its alloted commercial functions, which are to maintain its tensile strength, color, and resistance to wear for a reasonably long time.

Abacá fiber, as has been shown, is vegetable in its origin and chemically is composed to a very large extent of cellulose, in and with which is bound up a rather large number of chemical substances, both organic and inorganic, that in their entirety constitute the true fiber body, and through their varying amounts and combinations give rise to the many grades now recognized commercially. To determine how, when, and why abacá fiber became weak and discolored—that is, became damaged and perished, was the object of this investigation.

EXPERIMENTAL

On visiting the warehouses where large quantities of fresh abacá fiber were being received and classified daily it was obvious that the deterioration evidenced by some of the fiber had taken place in the provinces where the fiber was produced. On visiting the provinces and studying the methods of fiber production it was equally certain that damaged fiber was also coming into the provincial warehouses accompanying the strong fiber in varying amounts and showing different degrees of deterioration. Allowing for the relatively short time factor involved the damage was apparently caused by either chemicals or fermentation, and in as much as all damaged fiber was less valuable than undamaged fiber it seemed only reasonable to ascribe the

deterioration to nothing deliberately brought about by anyone but to incidental commercial conditions of fiber production as practiced, hence the use of chemicals was impossible, and therefore the presence and agency of active ferments in causing fiber deterioration became a working hypothesis.

A study of the fiber-stripping process as carried out in the abacá districts shows that some 85 per cent of the abacá plant, felled for stripping, after the fibrous layers, or tuxies, have been removed, is left on the ground around the growing and immature plants, where it promptly ferments and decays, and in the course of a few months is again absorbed by the soil as new plant food. Therefore, the growing plants are always surrounded by fermenting material, and to demonstrate the presence of the active agents of fermentation, their method of action, and the results brought about by them was the next step.

The reduction of vegetable matter containing, as in the case of abacá, cellulose, carbohydrates, proteins, woody matter, and inorganic salts, to available plant food is chiefly brought about by the microörganisms called bacteria, often assisted by fungi, commonly known as mold. The differences between the bacteria and the fungi, both causing deterioration and decay, are many and well marked. The fungi, generally speaking, are plantlike in structure, being supported on appendages resembling roots, and reproducing by means of spores very rapidly, though their growth and multiplication are measured by days rather than by hours and minutes. Bacteria, on the other hand, are a much simpler form of vegetable life, in that they have no rootlike supports, many kinds in fact are even motile and reproduce by division, each new entity redividing as often as once every ten or fifteen minutes under favorable conditions, such as are furnished by the pulpy residual trunks from which the fiber layers are stripped and even by the freshly stripped, juice-saturated fibers themselves.

So fast working and complete is this bacterial action in all countries producing hard fibers, to which the many varieties of hemp belong, that it is made use of to free the fiber bundles from the pulpy, cellular matter surrounding them. In the Philippines the entire sisil and maguey fiber crop is produced by this fermentive process, or "retting" as it is called, the vital points of which are the following:

Great care in allowing the process to progress only far enough to soften and disintegrate the extraneous vegetable matter without acting

on the fibers themselves, for though the fiber is quite resistant and the last to soften and disintegrate, it will do so eventually.

Careful cleaning and washing of the retted fibers to free them of the still clinging cellular matter and especially to eliminate the acids formed through fermentive action, as these acids are recognized everywhere as the great destroyer of all kinds of vegetable fiber.

Careful thorough drying of the retted fiber after the washing is completed in order to kill all bacterial and other microörganisms still clinging in countless numbers to the wet fiber. Long and costly experience has shown that this is the cheapest and best way of ensuring long life and durability to the retted fiber.

In as much as the commercial methods of abacá production as now practiced made it not only possible but very probable that the above facts had a direct bearing on the causation and control of weak fiber, the relatively slower-acting and more-localized fungi were left for later investigations and attention was concentrated on the bacteria, the results of whose marvelous activity were in evidence everywhere in the abacá fields.

THE PRESENCE, THE CHARACTERISTICS, AND THE EFFECTS OF BACTERIA CAUSING ABACÁ FERMENTATION

COMPARATIVE BACTERIAL COUNTS FROM THE YOUNG LEAF, THE OLD LEAF, AND THE DRY STEM [1] OF ABACÁ

Twenty-four abacá plants, divided into two sets of twelve each, were used for experimentation. The two sets were located some distance apart, so that the local conditions of each would be different.

Round pieces, about 8 millimeters in diameter, of the young leaf, the old leaf, and the dry stem were punched out by means of a sterile cork borer and well washed in equal amounts (about 10 cubic centimeters) of sterile water, from which 0.5 cubic centimeter was planted on plain agar for colony count. The reading was made after forty-eight hours with the results recorded in Table 1.

The experiment shows in a more or less uniform manner that bacteria exist in innumerable amount in the dry stem and that more bacteria are found in the young leaf than in the old leaf. Expressing the result graphically we have—

$$\text{Dry stem} > \text{Young leaf} > \text{Old leaf} >.$$

[1] The dry stems referred to in these experiments were those that are always found clinging to the outside of the trunk after the leaf itself has died and fallen. When the plant is cut down for stripping the dried portion is discarded.

TABLE 1.—*Bacterial colonies on young leaf, old leaf, and dry stem of abacá.*

	Colonies.			Colonies.	
	On plate.	Per cubic centimeter.		On plate.	Per cubic centimeter.
I. Young leaf	763	1,526	1. Young leaf	360	720
Old leaf	7	14	Old leaf	3	6
Dry stem	954	1,808	Dry stem	(a)	(a)
II. Young leaf	22	44	2. Young leaf	4	8
Old leaf	6	10	Old leaf	14	28
Dry stem	163	326	Dry stem	(a)	(a)
III. Young leaf	2	4	3. Young leaf	5	10
Old leaf	6	12	Old leaf	5	10
Dry stem	38	76	Dry stem	(a)	(a)
IV. Young leaf	60	120	4. Young leaf	954	1,808
Old leaf	3	6	Old leaf	14	28
Dry stem	4,579	9,158	Dry stem	(a)	(a)
V. Young leaf	2	4	5. Young leaf	4	8
Old leaf	0	0	Old leaf	35	70
Dry stem	11,448	22,896	Dry stem	(a)	(a)
VI. Young leaf	5	10	6. Young leaf	20	40
Old leaf	0	0	Old leaf	5	10
Dry stem	826	1,652	Dry stem	(a)	(a)

[a] Innumerable.

IDENTIFICATION OF THE BACTERIAL FLORA FOUND ON THE GROWING PLANT

Experiments to isolate and identify the different kinds of bacteria growing on plain agar were made as follows:

From the fermentation tubes containing pieces of the young leaf, old leaf, and dry stem, after twenty-four hours incubation, a loopful was taken and planted on plain agar plate. The latter was incubated for forty-eight hours. At the end of that time, different looking colonies were fished out and planted on plain agar slant. The identification of the different bacteria was worked out by their morphology, staining characteristics, sugar reactions, and other biological characteristics. The unidentified bacteria were classified according to Bergey's Manual of Determinative Bacteriology.

The following bacteria isolated were readily identified:

Staphylococcus aureus.—Coccus in graplike clusters producing a golden-yellow growth on agar.

Staphylococcus citreus.—Coccus in grapelike clusters producing a lighter lemon-yellow growth on agar.

Staphylococcus albus.—Coccus in grapelike cluster arrangement producing a white growth. The staphylococci are non-gas producers but attack carbohydrates forming acid in dextrose, lactose, and saccharose.

Bacillus prodigiosus.—Motile rod-shaped bacillus producing a red pigment on agar. It produces a small amount of carbon dioxide (CO_2) gas in dextrose broth.

There were other chromogenic bacilli isolated which needed further tests for their identification. All of them belong to the genus *Flavebacterium*, possessing feeble power of attacking carbohydrates. Some of them present sugar reactions identical with the pineapple brown rot. (See Table 2.)

All the bacteria mentioned in Table 2 belong to the genus *Flavobacterium*, defined as rod-shaped bacteria of medium size without endospores forming a yellow to orange pigment on culture media. Characterized by feeble powers of attacking carbohydrates, occasionally forming acid from dextrose but no gas. Motile or nonmotile and generally Gram negative. I–OL_1 and III–YL_1 have the same sugar reactions, identical with those of the pineapple brown rot.

There were also nonchromogenic and nonspore-producing bacteria found in the young and the old leaves and the dry stem of abacá. *Bacillus lactis aerogenes*, a powerful gas-producing bacterium, was the principal one; it was numerous especially in the dry stem and the young leaf. (See Table 3.)

The first set, IV–DS_3, has practically the same biological characteristics as *B. dysenteriae* Shiga except that it does not agglutinate with antidysenteric serum and the growth on agar is more abundant than that of *B. dysenteriae*. It should, therefore, belong to the genus *Eberthella*, the members of which are motile or nonmotile, Gram-negative rods growing well on artificial media, attacking a number of carbohydrates; acid being formed in dextrose but no gas, and do not form acetyl methyl carbinol.

The second set, I–DS_1, is a Gram-negative rod growing well on artificial media, attacking many carbohydrates, forming acid and gas in dextrose, and producing acetyl methyl carbinol. The sugar reaction and other biological characteristics exactly correspond to those of *B. lactis aerogenes*.

The third set, I–DS_2, is similar to the preceding in its biological characteristics except that it produces acid and gas in dulcite and the growth on agar is scanty. It therefore belongs with the preceding to the genus *Aerobacter*.

The last set, II–DS_3, is a Gram-negative rod, very motile, does not form acetyl methyl carbinol, and does not ferment any of the carbohydrates. It apparently belongs to the genus *Alcaligenes* and is possibly identical with *B. alcaligenes bronchisepticus*, which does not reduce nitrates and does not liquefy gelatin.

TABLE 2.—*Chromogenic bacteria on the young leaves, the old leaves, and the dry skin (genus Flavobacterium).*

[YL, young leaf; OL, old leaf; DS, dry stem.]

Kind.	Morphology.	Slant agar.	Gram.	Motility.	Nitrate reduction.	Acetyl methyl carbinol.	Indol.	Blood serum.	Gelatin liquefaction.	Litmus milk.	Glucose.
$II-DS_4$ ... $5-OL_2$ ...	Coccobacillus; occurring singly and in irregular clumps.	Abundant growth; light brown; moist and smooth.	—	—	—	—	—	—	—	(b)	—
$4-DS_2$	Short slender rods; arranged singly.	Yellowish brown; flat with finely serrated margin; surface smooth and moist.	—	—	±	—	—	—	—	(b)	+
$IV-DS_2$	Medium-sized rods resembling *B. typhosus*; arranged singly and in irregular clumps.	Light cream; slightly raised, with undulate margin.	—	—	—	—	—	[a]+	++	(c)	—
$6-DS_1$ ... $IV-DS_1$ ... $V-OL_2$ ...	Short plump rods; arranged singly and in clumps.	Lemon yellow; filiform growth; smooth and moist.	—	—	—	—	—	—	—	(c)	—
$II-YL_4$ ... $II-DS_2$	Short plump rods, some coccoid; arranged in short chains and some in clumps.	Bright orange; granular center.	—	—	—	—	—	—	±	(b)	—
$I-OL_1$ $III-YL_1$ ...	Short plump rods, others appear as coccobacilli; arranged singly.	Light brown; abundant, moist, and smooth.	—	—	—	—	—	—	—	(c)	—

[a] Liquified. [b] No change. [c] Color reduced to white.

Kind.	Morphology.	Slant agar.	Mannite.	Maltose.	Xylose.	Dulcite.	Lactose.	Saccharose.	Salicin.	Dextrin.	Russell.
II-DS_4; 5-OL_2	Coccobacillus; occurring singly and in irregular clumps.	Abundant growth; light brown; moist and smooth.	—	—	—	—	—	—	—	—	— —
4-DS_2	Short slender rods; arranged singly.	Yellowish brown; flat with finely serrated margin; surface smooth and moist.	—	+	—	—	—	—	—	—	— —
IV-DS_2	Medium-sized rods resembling *B. typhosus*; arranged singly and in irregular clumps.	Light cream; slightly raised, with undulate margin.	—	—	—	—	—	—	—	—	— —
6-DS_1; IV-DS_4; V-OL_2	Short plump rods; arranged singly and in clumps.	Lemon yellow; filiform growth; smooth and moist.	—	—	—	—	—	—	—	—	— —
II-YL_6; II-DS_1	Short plump rods, some coccoid; arranged in short chains and some in clumps.	Bright orange; granular center.	—	—	—	—	—	—	—	—	— —
I-OL_1; III-YL_1	Short plump rods, others appear as coccobacilli; arranged singly.	Light brown; abundant, moist, and smooth.	—	+	+	—	—	+	—	—	+ +

TABLE 3.—*Nonchromogenic and nonspore-producing bacteria found in the young leaves, the old leaves, and the dry stem of abacá.*

	Morphology.	Slant agar.	Gram.	Motility.	Nitrate reduction.	Acetyl methyl carbinol.	Indol.	Blood serum.	Gelatin liquefaction.	Litmus milk.	Russell.
IV-DS₁ I-YL₂ III-YL₂ I-YL₁ 3-YL₃ 6-YL₁	Coccobacillus; arranged singly and in irregular clumps; no agglutination to antidysenteric serum.	Abundant growth; moist, white, and opaque; undulating margin.	—	—	—	—	—	—	—	(a)	±
I-DS₁ 5-DS₁ I-YL₁	Coccobacillus; arranged singly and in irregular clumps.	Abundant growth; moist, white, and opaque.	—	—	+ –	+	—	—	—	b – +	+
I-DS₂ V-DS₂ 2-YL₁	Medium-sized rods resembling *B. typhosus*.	Scanty growth; filiform, smooth, moist, and grayish white; translucent.	—	—	+ –	+	—	—	—	b + +	+ +
II-DS₃ V-DS₂ 5-OL₁	Medium-sized rods; arranged singly and in irregular clumps.	Grayish white; translucent; flat growth; smooth and moist surface.	—	+ +	—	—	—	—	—	(a)	— —

a No change. b Coagulation. c Turning green.

	Morphology.	Slant agar.	Adonite.	Glucose.	Mannite.	Maltose.	Xylose.	Dulcite.	Lactose.	Sucrose.	Salicin.	Dextrin.
IV-DS$_3$; I-YL$_2$; III-YL$_2$; I-YL$_1$; 3-YL$_2$; 6-YL$_1$	Coccobacillus; arranged singly and in irregular clumps; no agglutination to antidysenteric serum.	Abundant growth; moist, white, and opaque; undulating margin.	—	+	—	—	—	—	—	—	—	—
I-DS$_1$; 5-DS$_1$; I-YL$_3$	Coccobacillus; arranged singly and in irregular clumps.	Abundant growth; moist, white, and opaque.	+	—	—	+	+	—	+	+	—	+
I-DS$_2$; V-DS$_1$; 2-YL$_2$	Medium-sized rods resembling *B. typhosus*.	Scanty growth; filiform, smooth, moist, and grayish white; translucent.	+	+	+	+	+	—	+	+	+	+
II-DS$_2$; V-DS$_2$; 5-OL$_1$	Medium-sized rods arranged singly and in irregular clumps.	Grayish white; translucent; flat growth; smooth and moist surface.	—	—	—	—	—	—	—	—	—	—

Spore-bearing bacteria belonging to the *subtilis* group were also present. They are especially numerous in the dry stem and the old leaf. They do not produce acid or gas.

GAS-PRODUCING BACTERIA AND THEIR DISTRIBUTION ON THE GROWING PLANT

Taking advantage of the well-known characteristic of *Bacillus lactis aerogenes* and allied species to produce gas in media containing carbohydrates, their relative distribution on the various parts of the growing plant was determined by this means.

Pieces of the young leaf, the old leaf, and the dry stem were placed in separate fermentation tubes. These specimens were taken from the twelve plants used in the preceding experiment. The amount of gas produced was noted after twenty-four hours, seventy-two hours, and a week of incubation at 37° C. The fermentation tubes contained nutrient bouillon with 1 per cent lactose titrated to +1 reaction. Table 4 shows the results of the experiment.

TABLE 4.—*Gas produced in fermentation tubes after various periods.*

FIRST SET. DECEMBER 24, 1926.

Plant.	Young leaf.			Old leaf.			Dry stem.		
	24 hours.	72 hours.	1 week.	24 hours.	72 hours.	1 week.	24 hours.	72 hours.	1 week.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
I	6	33	38	27	85	85	27	42	50
II	13	52	52	19	32	60	26	62	78
III	13	58	58	19	32	65	46	77	80
IV	21	85	85	40	42	55	17	42	46
V	8	31	33	17	46	85	19	62	80
VI	3	28	32	21	46	46	23	44	68
SECOND SET. JANUARY 17, 1927.									
1	0	26	32	17	56	77	33	73	77
2	17	56	58	9	17	19	21	65	77
3	18	62	70	20	40	43	32	40	43
4	11	55	62	12	17	62	0	32	65
5	6	29	36	0	65	65	29	49	58
6	0	8	12	13	29	29	58	78	80
Average	9.6	43.5	47.3	17.8	42.2	57.5	27.5	55.5	66.8

The results show that gas is produced by bacteria found in the dry stem, the old leaf, and the young leaf and that the gas produced by the dry stem is more than that from the old

leaf, and that from the old leaf is more than from the young leaf. Expressing the results graphically, we have after twenty-four hours and one week incubation—

Young leaf + < Old leaf + < Dry stem +.

After seventy-two hours incubation the result is irregular. These results appear contradictory to the first experiment where we had—

Dry stem > Young leaf > Old leaf.

The foregoing, however, referred to quantity numbers of bacteria, while in the latter the amount of gas is determined by the amount of fermentable substance present as well as by the number of bacteria, and these two factors modify the results as shown.

BACTERIAL CONTAMINATION OF FIBER THROUGH THE STRIPPING PROCESS

The abacá field having shown itself to be a hot bed of bacterial action it necessarily follows that in as much as no attempts are ever made to protect the abacá fiber from contamination during the stripping process, all the fiber would probably be more or less heavily infected by bacteria.

To get at the relative amount of infection suffered by the fiber coming from the various layers of the stalk, that is, outside, middle, and inner layers, the following objectives were planned and carried out:

RELATIVE CONTAMINATION AS MEASURED BY GAS PRODUCTION

During the process of stripping, about equal pieces of all the important parts were taken with all aseptic precautions and placed in fermentation tubes containing nutrient bouillon with 1 per cent lactose titrated to + reaction. The gas produced was measured after twenty-four and forty-eight hours incubation at 37° C. with the results recorded in Table 5.

TABLE 5.—*Gas production after incubation in fermentation tubes for twenty-four and forty-eight hours.*

	24 hours.	48 hours.		24 hours.	48 hours.
	P. ct.	*P. ct.*		*P. ct.*	*P. ct.*
1. Young leaf	1.5	33	7. Outer tuxie	0	7
2. Old leaf	11.5	24	8. Middle tuxie	0	0
3. Dry stem	16.3	72	9. Inner tuxie	0	0
4. Young skin	3	3	10. Outer fiber	6	72
5. Sap	0	0	11. Middle fiber	2	35
6. Heart of stem	0	0	12. Inner fiber	1	56

Expressing the results graphically after twenty-four hours incubation in the raw material—

Dry stem + > Old leaf + > Young skin + > Young leaf +.

The heart of stem, sap, outer tuxie, middle tuxie, and inner tuxie remain without gas even after forty-eight hours except the outer tuxie.

In the case of the finished fiber—

Outer fiber + > Middle fiber + > Inner fiber + .

The experiment shows that while the gas-producing bacteria are ever present in the outside layers of the stalk, inner tuxies from which the finer fibers are stripped are comparatively free from them. In the process of stripping, however, all the finished fibers become infected with the gas-producing bacteria.

COMPARATIVE BACTERIAL COUNTS FROM INFECTED PARTS

Equal pieces of the different parts of abacá were well washed, each in 10 cubic centimeters of sterile water. From each of the waters 0.5 cubic centimeter was planted on plain agar for colony count after forty-eight hours incubation.

TABLE 6.—*Colonies on plain agar after incubation for forty-eight hours.*

Portion.	Colonies—		Portion.	Colonies—	
	On plate.	Per cubic centimeter.		On plate.	Per cubic centimeter.
1. Young leaf	10	20	7. Outer tuxie	14	28
2. Old leaf	36	72	8. Middle tuxie	4	8
3. Dry stem	([a])	([a])	9. Inner tuxie	3	6
4. Inner stem	43	86	10. Outer fiber	168	336
5. Sap	72	144	11. Middle fiber	6	12
6. Heart of trunk	1	2	12. Inner fiber	3	6

[a] Innumerable.

Expressed graphically—

Dry stem > Inner stem > Old leaf > Young leaf;

Outer tuxie > Middle tuxie > Inner tuxie > Heart of trunk;

Outer fiber > Middle fiber > Inner fiber;

Sap > Inner stem.

IDENTIFICATION OF THE PRINCIPAL KINDS OF BACTERIA PRESENT

Attempts to isolate the principal kinds of bacteria growing in the fermentation tubes showing gas after forty-eight hours incubation were made, using Teague-medium plates. The principal and most abundant kind of colonies were fished out and planted on slant agar. Subsequent identification was under-

taken with the results recorded in Table 7. The biological characteristics are recorded in Table 8.

TABLE 7.—*Identification of bacteria.*

Isolated from—	Kind.	Appearance on Teague plate.
Young leaf; Dry stem; Outer tuxie; Outer fiber; Middle fiber; Inner fiber	1. *Bacillus lactis aerogenes*	Large colonies; rosy red, round, smooth, much raised, and very moist.
	2. *Bacillus prodigiosus*	Dark purple, moist, round colonies.
Old leaf	1. *Subtilis* group (b) *Bacillus megaterium.*	Small round colonies; dark purple with refracted light and a greenish dry metallic luster resembling *B. coli.*
	2. *Bacillus bronchisepticus*	Small round entire colonies, grayish white; moist and smooth surface.
Inner stem	1. Eberth group	Small grayish white colonies; transparent and flat; serrated margin.
	2. Identical with pineapple brown rot bacillus.	Perfectly round colonies; much raised; moist; brownish with reflected light; with refracted light the center is dark purple and the periphery grayish white.

THE EFFECT OF DRYING FRESH FIBER ON ITS NORMAL BACTERIAL CONTAMINATION

Observations made in the field and supported by the foregoing experiments appear to show that all commercial abacá fiber produced by present methods of stripping is more or less heavily contaminated with bacteria, and that the juice and soluble substances accompanying the fiber furnish the media for their prompt and vigorous growth. Drying, or the process in commercial fiber production that follows the stripping (where the bacterial contamination takes place), is therefore of great importance, as it determines whether the bacteria shall live and cause damage or die and become harmless.

The following experiments were undertaken to show the various effects of thorough and prompt drying on the bacteria normally present, so to speak, on the fiber. Attention is called to the two phases that developed as the experiment progressed. The first was the increasing mortality as drying progressed up to the seventh day. On that day the second phase appeared, due to the fact that rains caused a sudden increase in relative humidity, the fiber reabsorbed moisture and the remaining bacteria not only lived but promptly began their multiplication by division.

TABLE 8.—*Biological characteristics of bacteria.*

	Colonies on Teague plates.	Slant agar.	Morphology.	Gram.	Motility.	Litmus milk.	Gelatin liquefaction.
Young leaf I	Exuberant growth. Large round colonies. Much raised with entire margin. Rosy-red color; smooth and very moist.	Abundant, opaque, white, moist, smooth surface and spreading.	Slender rods about the size *B. typhosus* occurring singly and irregular clusters.	—	—	Acidity with coagulation.	—
Young leaf II	Dark purple, moist, round colonies; entire margin.	Blood-red; growth moist and spreading.	Short slender rods occurring singly.	—	+	Acidity present.	[a] +
Old leaf I	Small round and flat colonies with a dark purple color. Surface has greenish metallic luster like *B. coli*.	Opaque cream color; growth moist; slightly granular surface.	Thick bacillus with central spores like *B. subtilis* arranged in short chains. After 3 days they appear as globular bodies without any stain and arranged singly and in short chains.	-	[b] +	Acidity very slight.	+
Old leaf II	Small round colonies; slightly raised and entire margin; grayish white in color; moist and smooth surface.	Filiform growth, grayish white, moist, glistening surface. Margin smooth.	Fine short and slender bacilli (rods) occurring singly and irregular clusters.	—	+ +	No change	—
Inner stem I	Small colonies; flat with serrated margin, transparent and grayish white in color.	Flat but spreading grayish white growth, transparent and serrated margin.	Short slender rods occurring singly and in irregular clumps.	—	— + +	do	—
Inner stem II	Large colonies; round entire margin; much raised, moist surface; brownish in color with reflected light; dark purple center, grayish white periphery with refracted light.	Abundant brownish growth, moist, smooth surface and margin.	Short fine rods occurring singly and irregular clumps.	—	+	Acidity slight	—

[a] Red surface.

[b] Slow wormlike motion.

[c] Turning green.

	Blood serum.	Indol.	Nitrate reduction.	Acetyl methyl carbinol fast.	Russell.	Glucose.	Mannite.	Maltose.	Xylose.	Dulcite.	Lactose.	Sucrose.	Salicin.	Dextrin.	Adonite.
Young leaf I	—	—	+	+	+	+	+	—	+	—	+	+	+	+	+
Young leaf II	—	—	+	—	+	—	—	+S	—	—	—	+	—	—	—
Old leaf I	—	—	—	—	—+S	—	—+S	—	—	—	—	—	—	—	—
Old leaf II	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Inner stem I	—	—	—	—	—	—	—	—	—	—	—	°—	—	—	—
Inner stem II	—	—	+	+	—	—	—	+	—	—	—	+	—	—	—

The freshly stripped fiber was classified into outer, middle, and inner fiber, derived from outer, middle, and inner tuxies, respectively. These were hung up in the room with free air access. About equal portions of each were cut each day and suspended and well washed in 10 cubic centimeters of sterile water; then relative bacterial counts were made on plain agar after forty-eight hours incubation. The results are recorded in Table 9.

From the above experiment we may draw the following conclusions:

That as drying progressed the bacterial contamination was gradually reduced, reaching the minimum after seven days hanging in the room. After the first day the fiber samples were "commercially dry," but it is very evident that this is not enough to reduce the bacterial count sufficiently and that longer drying or direct sunlight is highly desirable.

That the fibers, both the freshly made as well as the commercially dry, are invariably contaminated with bacteria capable of producing fermentation as soon as moisture is sufficiently increased.

That the outer fibers contain the greatest and the inner fibers contain the least number of bacteria.

THE EFFECT OF FERMENTATION BY ABACÁ BACTERIA ON FIBER IN VARIOUS STAGES OF DRYING AND STORAGE

THE EFFECT OF FERMENTATION ON FRESHLY STRIPPED FIBER

Hanks of freshly stripped, mature fiber of mixed grade were selected, the moisture contents being arranged as follows:

1. Was "wringing wet" or just as it came from the stripping knife, and contained at least 50 per cent juice.
2. Had been partially dried so that it contained some 20 per cent juice.
3. Was part of No. 2 but had been moistened with clean river water so as to contain about 40 per cent moisture.

These hanks were carefully wrapped in fresh abacá leaves to prevent outside soiling, then covered with the waste material discarded by the stripping knives and left there. This waste material, made up of discarded fiber, pulpy material, and plant juices, was fermenting so rapidly that it was distinctly warm. The results of the fermentation on these fibers induced through the ordinary infection received from stripping, handling,

TABLE 9.—*Experiments to show the effects of thorough and prompt drying.*

Day.	Portion.	Gas after 24 hours.	Gas after 48 hours.	Relative bacterial count per cubic centimeter.
		Per cent.	*Per cent.*	
First	Outer fiber	6	72	336
	Middle fiber	2	35	12
	Inner fiber	1	56	6
Second	Outer fiber	1.5	19.2	10
	Middle fiber	0	0	2
	Inner fiber	0	23	8
Third	Outer fiber	0	16	4
	Middle fiber	0	4	0
	Inner fiber	0	4	4
Fourth	Outer fiber	3	12.3	8
	Middle fiber	0	0	2
	Inner fiber	0	6	2
Fifth	Outer fiber	0	3.8	6
	Middle fiber	0	0	2
	Inner fiber	0	0	2
Sixth	Outer fiber	0	3	4
	Middle fiber	0	0	2
	Inner fiber	0	0	2
Seventh	Outer fiber	0	0.8	2
	Middle fiber	0	0	0
	Inner fiber	0	0	0
Eighth	Outer fiber	0	0	2
	Middle fiber	0.8	9	2
	Inner fiber	0	0	0
Ninth	Outer fiber	0	20.7	4
	Middle fiber	0	0	0
	Inner fiber	0	7.6	4
Tenth	Outer fiber	0	0	4
	Middle fiber	0	11.5	12
	Inner fiber	0	7.6	2
Eleventh	Outer fiber	0	0	2
	Middle fiber	0	3	4
	Inner fiber	0	0	4
Twelfth	Outer fiber	0	3	12
	Middle fiber	0	7.6	6
	Inner fiber	0	0	2

and wrapping in the abacá leaves could be summed up as follows:

1. After two days it had developed a volatile acid odor that slowly disappeared on exposure to the air. The color of the well-cleaned fiber was almost unchanged, but the strippy parts showed a brownish yellow color that deepened on exposure to the light. The acid contents when titrated had increased three to

four times in amount over the part kept in reserve and promptly dried. The fiber was strong when first removed, but in three months it became so brittle and weak that a large part could be classed as damaged.

2. This was kept six days covered by the waste when unforseen conditions made its removal necessary. It was found to be of good color, only slightly increased in acidity, and in three months only a very small number of fibers showed weakness. The drying, although not complete, had evidently increased its resistance to a marked degree over the undried fiber.

3. When removed, also after six days, this fiber had a good color, but the acid contents were doubled, and after three months a considerable number of fibers, especially the strippy grades, became weak and went down in color.

THE EFFECT OF FERMENTATION ON WET WAREHOUSE FIBER

A warehouse fire in Manila, in which many hundred bales of abacá, both U. S. and U. K. grades, were damaged, made possible the following test: The fire smoldered among the high piles of bales for nearly a week, necessitating flooding them until everything was soaked. The rattan bands of most of the bales were burned so that the bales fell apart, and while much of the surface fiber was burned or charred, most of the inside fiber remained untouched, except that it was water soaked. This fiber was removed from the warehouse by the hank, wet and cold, and thrown into piles outside. A pile some 4 meters high was selected and an iron pipe driven down near the center so the temperature could be taken daily. The temperature outside averaged about 28° C. although sun and rain changed this somewhat. The temperature at the bottom of the pipe began to rise very soon, gained a little every day, and in one week registered 67° C. After that it declined each day, at a slower rate. Unfortunately, the pile had to be broken down at the end of two weeks. The changes in the acidity of the fermenting fiber were also noted, for tests of the fiber when it went to the pile showed it to be low in acidity probably on account of the dissolving action of the water. After fermentation in the pile began in earnest the acidity continued to rise for a week when it was four to five times more than that at the beginning. After that it steadily decreased until the day before the pile was broken down when the fiber withdrawn reacted slightly alkaline. Needless to say most of this fiber after drying was perished, yet considerable was also found that was still strong to hand test-

ing, showing the resistance of certain fibers even to the worst possible conditions.

This increase followed by decrease in acidity and finally the presence of alkalinity is perhaps explained by the well-known fact that ordinary mixed fermentation is acid in character, due to the breaking down first of the more easily decomposed carbohydrates and other bodies that give acid products, but after these have been acted upon, the bacteria attack the nitrogenous matter and form products which ultimately react alkaline, and neutralize the acids first formed.

THE EFFECT OF FERMENTATION ON THE WATER-SOLUBLE CONSTITUENTS OF HIGH- AND LOW-GRADE FIBER

To throw additional light on the apparently complicated bacterial action above described, experiments were tried on a small scale with the soluble constituents only, of several grades of fiber, to see if they also increased and decreased in acidity as fermentation progressed.

TABLE 10.—*The total acidity of 10 grams of fiber of each grade, expressed in cubic centimeters of alkali used.*

	Sample 1, AA grade.	Sample 2, L_1 grade.	Sample 3, J_1 grade.
	cc.	*cc.*	*cc.*
Unfermented	1.00	6.50	0.50
First day	2.50	6.00	0.50
Second day	2.25	6.25	
Third day	1.50	4.50	1.00
Fourth day	1.50	5.50	5.50
Fifth day	1.00	5.00	3.00
Sixth day			2.25
Seventh day	0.75	5.50	2.00
Eighth day			2.00
Ninth day	0.50	5.25	2.00
Fourteenth day	0.10	1.50	1.80

One hundred grams of each sample were cut into small pieces, and in suitable glass containers each was extracted with 2 liters of distilled water for three hours on the water bath. The solutions were then poured off, concentrated at low heat to 500 cubic centimeters, and after sterilization in a pressure autoclave for fifteen minutes at 15 pounds pressure were inoculated with equal amounts of a culture of *Bacillus lactis aerogenes*. Incubation was made at 37° C.

For determination of total acidity aliquot parts of the solutions were titrated with decinormal sodium hydroxide, using phenolphthalein as indicator. The figures given in Table 10

represent the total acidity of 10 grams of the fiber of each grade expressed in cubic centimeters of alkali used.

While the rise and fall in the total acidity of the water-soluble constituents of the fiber during fermentation appeared to take place in a manner quite similar to that noted in experiment B, the solutions always remained acid as long as the experiment continued, from which it may be inferred that the bacteria subsequently attacked the insoluble constituents of abacá after the soluble ones had been consumed and this secondary attack gave rise to alkaline products of fermentation.

THE EFFECT OF FERMENTATION ON BALED FIBER

For this purpose ten bales of recently received Bicol fiber, consisting of two bales each of grades F, I, J^1, J^2, and L_1, were opened two by two, the contents thoroughly mixed and then divided again into piles of one bale each, each grade by itself. The moisture content of each bale was determined in the laboratory and enough tap water was sprinkled on one pile of each grade to bring the moisture content up to approximately 20 per cent. The fiber was then all rebaled and stored together where the air circulated freely in a clean dry warehouse during the rainy months of July, August, and September. An iron pipe was so arranged in each bale during the bailing that the temperature in the center of each bale could be taken daily. It was found in the dry bales that no rise of temperature took place or at most one degree in three bales, yet this rise stayed constant in some bales for two weeks when it again became normal. The wet bales, especially the three lower grades, rose from 3 to 4° C., and after continuing that way for a week gradually subsided to normal at the end of the first month. The heat of fermentation by that time probably only equalled the conductivity of the fiber itself as in the case of the dry bales.

On reweighing, previous to inspection, it was found that the dry bales had gained, on an average, 5 kilograms, while the wet bales had lost 3.5 kilograms. The two bales of each grade were opened at the same time and again graded by the same expert that had selected the fiber in the beginning. Summarizing the results, the important changes that had taken place were the following:

The odor of all dry bales was good—that of the wet bales in every case musty or moldy and in the J^1 and L_1 bales was disagreeably sour also. The color of all dry bales was off slightly on yellow or down somewhat for the L_1. The wet bales were off 12.5 to 25 per cent for the higher grades while the lower grades were much too badly off.

The tensile strength by hand testing showed F dry to be unchanged and I dry was still good, but the rest had all gone down, the worst one, L wet, being 80 per cent weak and the worst of the dry was J[1], which was almost half weak.

The microscopical examination of the fibers disclosed the fact that all, with the exception of the F bales and the I dry, were infected with active bacteria as well as fungi.

In acidity the high grades, both wet and dry, had increased but little, while the lower grades had all increased—the wet ones more than the dry, the worst being L wet, which gained four and one-half times.

THE EFFECT OF FERMENTATION ON THE TENSILE STRENGTH OF FIBER

The fiber from two mature abacá plants was carefully mixed so as to be uniform; it was then divided into five portions, each being enough to fill a large Mason jar. One portion was air dried at once, while the rest were sterilized in a pressure autoclave in the tightly closed Mason jar for fifteen minutes at 15 pounds pressure. After cooling they were infected, one with *B. lactis aerogenes*, and one with a spore-bearing air-borne variety of bacterium very prevalent in the abacá fields. One of the two remaining full jars was dried at once, while the other was placed unopened in the incubator with the infected jars and all three were incubated for six days.

After drying, examining, and testing at the end of six days the results recorded in Table 11 were obtained.

TABLE 11.—*Strength and condition of fiber at the end of six days.*

Sample No.	Tensile strength per gram meter.	Color.	Remarks.
	Kilos.		
1	49.36	Regular for J_1 grade	The freshly stripped portion dried at once.
2	49.70	Regular for J_1 grade	Portion sterilized and then dried.
3	48.91	Slightly down	Portion sterilized and incubated, then dried.
4	42.25	Reddish brown; down to Le	Portion infected with *B. lactis aerogenes.*
5	38.32	do	Portion infected with spore-bearing air-borne bacteria.

The tensile strength of the first three samples is probably close enough to be within the limit of error of the experiment, while that of the fourth and the fifth is shown to be decidedly lowered.

PROGRESSIVE LOSS OF TENSILE STRENGTH CAUSED BY THE PRODUCTS OF FERMENTATION

A small hank of perished L fiber was selected, which showed by chemical and microscopical examination that it had gone down in color and tensile strength through intensive bacterial action followed by mold action, and had an acidity some seven times that of normal fiber. It was extracted with warm distilled water and the acid extract sterilized by boiling. A hank of excellent Samar E fiber was divided into two equal parts and one part was soaked in the above extract until the extract was all absorbed, after which the fiber was carefully dried at room temperature and hung up with the untreated half in a cool, dry place, where they were under the same conditions of storage. Each month these two half hanks were tested in a Louis Schopper fiber tester for tensile strength. In less than four months the acid half hank had lost 17.5 per cent of its original strength and the normal half 5.4 per cent. In six months the acid hank was mostly perished and completely so in less than a year. In the same time the normal hank went down at only the normal rate or a little over 9 per cent.

THE ACIDS OF FERMENTED AND UNFERMENTED FIBER

Pending further investigation no definite statement can be made as to the exact rôle played by bacteria in the destruction of abacá fiber with its attendant loss of tensile strength, lowering of color, luster, etc. From the experiments so far made it appears likely that this deterioration may be ascribed to the direct attack of the bacteria on the water-soluble constituents of the fiber, giving rise to various acid products, which in turn act chemically on the insoluble parts, changing them further into bacterial food.

In the preceding paper [2] it was shown, in the examination of a large number of samples of abacá fibers from different districts that their tensile strength was apparently inversely proportional to their total free acid contents, measured against standard alkali. Many other facts also point to the important rôle played by the free acids found in both the fermented and the unfermented fibers and consequently much time has been given to their study, isolation, and purification.

[2] Sherman and Sherman, this issue, 21–40.

SUMMARY

Due to the custom of all abacá growers in the Philippines some 85 per cent of the semiannual plant growth is cut down in the harvesting of the fiber and allowed to ferment and decay underneath the growing, immature plants.

The immediate locality where all the fiber is recovered and stripped is, therefore, a hot bed of bacterial infection, and all commercial fiber produced is heavily infected with bacteria.

The bacterial flora found on all exposed parts of the growing plant as well as on the produced fiber is diversified, large, and active.

The process of drying, which should immediately follow the stripping of the fiber, has for a direct result the practical sterilization of the fiber so long as it remains dry thereafter.

Failure to dry the fresh fiber promptly and thoroughly, or wetting after once dried, results in fermentation, the immediate effects of which are the production of increased acidity, lowering of tensile strength, change of color, decrease of luster—in other words, all of the phenomena that characterize damaged and perished fiber.

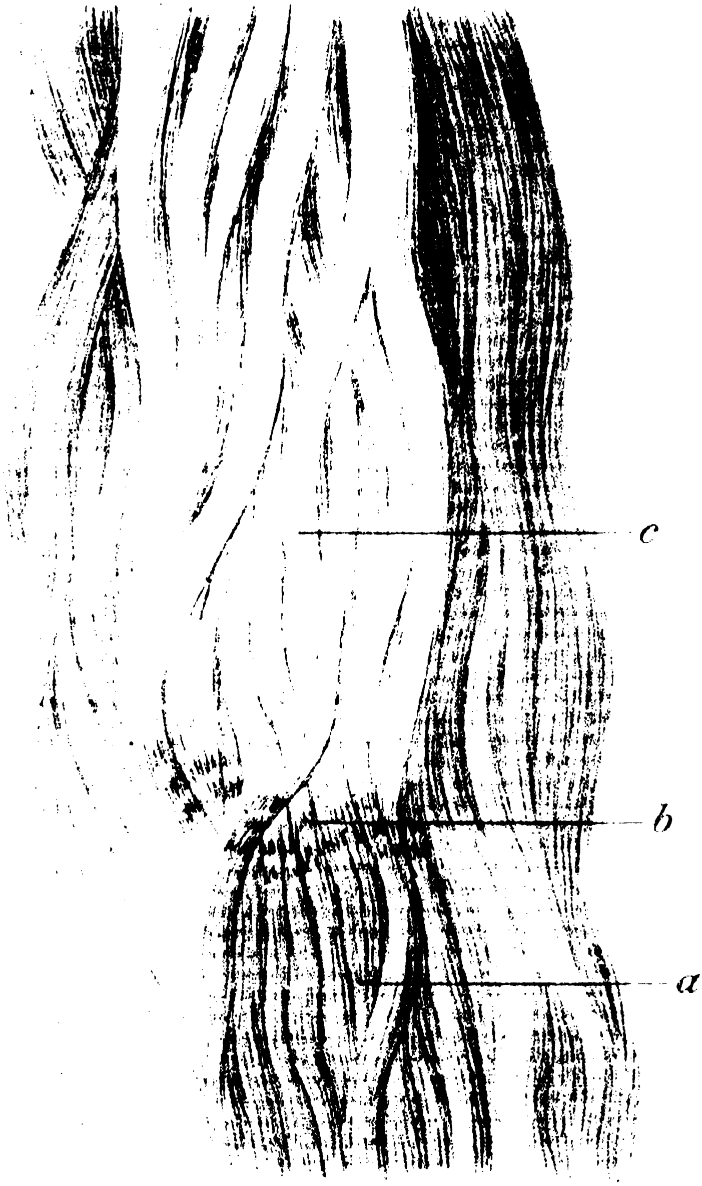
These damaging effects on the fiber appear to be caused by the acid fermentation products of its soluble constituents as well as by direct action of the bacteria on the fiber.

288244—5

ILLUSTRATION

PLATE 1

A hank of high-grade Davao abacá partially wet while baled, showing change of color due to bacterial action and mold growth; *a*, heaviest bacterial action where fiber was wettest; *b*, black-mold colonies; *c*, still dry, with original color.



A hank of high-grade Davao abacá partially wet while baled, showing change of color due to bacterial action and mold growth.

PLATE 1.

MERCURIC IODIDE IN THE TREATMENT OF EQUINE EPIZOÖTIC LYMPHANGITIS [1]

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Manila

ONE PLATE

Epizoötic lymphangitis is a chronic, infectious disease of horses and mules. Rarely the malady also occurs in man. It is caused by a type of yeast, *Blastomyces farciminosus* (*Cryptococcus farciminosus*), and is characterized by a purulent inflammation of the lymphatic vessels and regional lymph nodes of the subcutaneous tissues.

Epizoötic lymphangitis occurs in various parts of Europe, Asia, Africa, and South America. It does not at present exist in the United States. In the Philippine Islands the disease has long been a scourge of the equine population and, in so far as the military establishment is concerned, has proved to be one of the most troublesome conditions with which the Army veterinary service has had to contend.

While an enormous amount of work has been done by various investigators with a view to finding a satisfactory treatment for epizoötic lymphangitis, the results have been quite discouraging. Prompt and thorough surgical interference has given fair results. However, where the involvement is extensive, surgery is not always feasible and at best it results in considerable scarring which, obviously, is undesirable if it can possibly be avoided.

Various chemical agents, such as bichloride of mercury, copper sulphate, phenol, mercury salicylate, iodide of potash, tartar emetic, atoxyl, salvarsan, etc., have been employed in the treatment of the disease. Reports on all of these chemicals are exceedingly variable as regards results obtained.

[1] Published with permission of the Surgeon General, United States Army, who is not responsible for any opinion expressed or conclusions reached herein.

Several years ago the United States Army Medical Department Research Board conducted a rather long series of experiments with a view to finding a satisfactory treatment for epizoötic lymphangitis. This work involved the testing of mercurochrome, gentian violet, various colloidal-silver preparations, gray oil, salvarsan, tartar emetic, potassium iodide, sodium iodide, etc. In some instances we appeared to get results while in others, with the same treatment, failures occurred. It was finally concluded that nothing we had worked with was as satisfactory as prompt and thorough surgical treatment, so the project was dropped.

In October, 1926, Nainsouta(1) published a report in which he indicated that red iodide of mercury, when administered intravenously, was highly effective in the treatment of epizoötic lymphangitis. As a matter of fact he considered that chemical specific for the treatment of the disease. In view of this report we decided to revive our lymphangitis project and test the action of mercuric iodide on some of our cases of epizoötic lymphangitis among Army horses.

In the beginning Nainsouta administered the drug in doses of 0.20 gram twice a week for five weeks. In grave cases he recommended doses of 0.50 gram. He employed 50 cubic centimeters of distilled water for the suspension of each dose of the chemical.

In our work we have found that daily intravenous doses of red iodide of mercury, suspended in 60 cubic centimeters of sterile distilled water, can be safely administered over a period of from seven to ten days. Further, after a lapse of two or three weeks this course of treatment can, if necessary, be repeated without untoward results.

In preparing and administering the chemical we have carried out the following procedure: The 0.50-gram dose of mercuric iodide is very carefully weighed and placed in a sterile Erlenmeyer flask containing 60 cubic centimeters of sterile distilled water. The flask is then shaken vigorously in order to make as fine a suspension of the chemical as possible. Before the drug has a chance to settle the mixture is poured into a Luer type, glass syringe and promptly injected into the jugular vein. Leaving the needle in the vein, the flask and the syringe are quickly washed with about 30 cubic centimeters of sterile physiological saline solution and this is injected, so that the animal gets the full dose of the iodide of mercury.

Great care must be exercised to absolutely insure that none of the chemical is injected into the vessel wall or surrounding tissues. A sterile needle that has not come in contact with the mercuric iodide suspension should be inserted into the jugular vein and a good, steady flow of blood noted before the syringe is attached for the injection. If in the meantime the mercury has settled in the syringe a little shaking just before attaching the syringe to the needle is desirable.

In treating cases of epizoötic lymphangitis it has been our practice to make a small incision in any soft nodules present, evacuate the pus, and then give the animal daily intravenous injections of the red iodide of mercury prepared as above described. In the case of average-weight and heavy horses ten daily injections can be safely given. Series of seven daily injections will ordinarily suffice for smaller horses unless the involvement is extensive in which case the ten injections can be given. The dose for Philippine ponies should not exceed 0.30 gram.

It is desired to emphasize the point that a second series of injections of mercuric iodide should not be commenced until at least two weeks after the completion of the first series.

To the present time nineteen cases of epizoötic lymphangitis have been treated by this method and the results have been highly satisfactory.

After the first few doses of the drug the smaller nodules start to diminish in size and gradually disappear. The larger nodes usually proceed to suppuration, and as soon as they are soft they should be opened. The pus from lesions in animals receiving the mercury treatment soon assumes an entirely different character from that of the untreated case. In the place of the very thick, creamy pus, the discharge from cases well along on the course of mercury treatment usually consists of a fairly fluid, serum-colored material containing small accumulations of pus in the form of white flocculi.

In our experience the course of treatment, in the average case, has extended over a period of not more than two months. In mild cases with minor involvement one course of seven to ten daily doses of the mercuric iodide will usually suffice. With the average case of moderate severity and involvement two courses of the drug with two or three weeks between courses are advisable. In severe cases with extensive involvement a third course may be necessary.

One should not fail to open nodes containing pus, especially the larger ones. This practice certainly aids in reducing the period over which the animal must be treated. A very small incision with a bistoury will prove satisfactory and will not be apt to result in a detectable scar.

The results we have obtained with this treatment are nicely illustrated by our case 7, a horse suffering from a moderately severe case of epizoötic lymphangitis. Plate 1 is from a photograph of the involved region of this animal just before we commenced the mercury treatment. The prominent nodes were incised, the pus evacuated, and daily intravenous injections of 0.50 gram of the mercuric iodide in 60 cubic centimeters of distilled water given over a period of ten days. After a period of two weeks a second course of ten injections was given. The animal started to improve after the fifth or sixth dose of the drug, and progress was continuous up to the end of the second course of treatment when the animal was about normal. However, he was kept under observation for two weeks more, and while probably unnecessary he was given four more daily doses of the mercuric iodide before being sent to work. Treatment of this horse started on September 1, 1927, and he was discharged as cured on October 23, 1927. To the present time there has been no recurrence of the condition.

Lately we have employed an equal part (0.50 gram) of potassium iodide with the mercuric iodide and reduced the amount of water used to 30 cubic centimeters. This gives a solution of the double iodide of mercury and potassium and is more readily administered than the suspension of mercuric iodide alone. This mixture has not been employed over a sufficient period to determine whether or not it is as satisfactory as the mercuric iodide alone. In previous work we have noted that some horses are rather sensitive to potassium iodide when given intravenously, so in some instances it may be desireable to omit the potassium iodide.

I wish to acknowledge my indebtedness to Lieut. Col. Burt English, department veterinarian, Philippine Department, and to Maj. D. B. Leininger, station veterinarian, Fort William McKinley, for their aid in carrying out this work.

REFERENCE

1. NAINSOUTA, R. Action spécifique du biiodure de mercure contra la lymphangite épizootique. Bull. Soc. Pathol. Exot., Paris 19 No. 8 (October, 1926).

ILLUSTRATION

PLATE 1. Involved area of a horse with epizoötic lymphangitis.

PLATE 1. INVOLVED AREA OF A HORSE WITH EPIZOOTIC LIMPHANGITIS.

NOTES ON PLASMOQUINE (PLASMOCHIN)[1]

By C. M. HASSELMANN and MARGARETE HASSELMANN-KAHLERT

Of Manila, Philippine Islands

ONE TEXT FIGURE

In 1640, Juan del Vego, attending physician to the Countess Anna del Cinchon, took the bark of *Cinchona* species from Ecuador to Europe. The derivation of the word quinine is still under discussion. Probably, this expression does not come from the name of the countess but from the word *knia*, (1) which means "bark" in the language of the old Peruvians. The duplication would signify, as in all primitive languages, only "of special importance;" as, for example, in the case of *tse-tse*, where *tse* in the language of the Zulu-Kafirs means "fly," and *tse-tse*, therefore, means a very important and dangerous fly.

Many attempts have been made to replace this febrifuge by other drugs. In 1820 Pelletien and Caventon isolated quinine from the bark. Quinine synthesis has been attempted many times since 1856 when Perkin, still thinking that quinine had two quinoline rings, succeeded in producing mauvëin, the first coal-tar dye.

It has long been known that quinine acts only upon the malarial schizonts; the sexual forms, especially the crescents in subtertian infection, are not destroyed. Thirty years ago Marchiafava and Bignami (2) said:

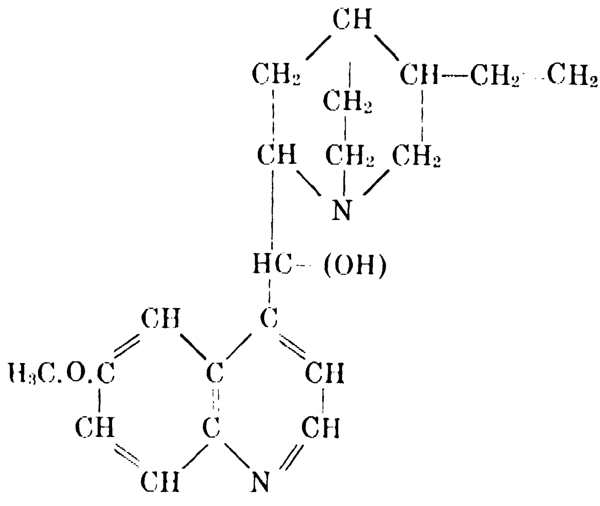
> The salts of quinine, even when given in doses as large as 2 grams a day, do not perceptibly affect the crescent forms of these parasites. Quinine

[1] Plasmoquine was first brought to the Philippines in December, 1926, by one of the authors (C. M. H.) and given to private patients, for both treatment and prophylaxis. These trials were again taken up when, during the summer of 1927, the then representative of the Bayer firm furnished a greater supply of the drug. Through the kindness of Dr. Jacobo Fajardo, director of the Philippine Health Service, and Dr. C. Gavino, director of San Lazaro Hospital, a greater number of malaria cases were treated with plasmoquine in addition to our private patients. Dr. C. Policarpio, Dr. J. Salta, and Dr. B. Barrera, all resident physicians of the hospital, gave us valuable coöperation. To all these we wish to express our sincerest thanks.

acts upon the malaria parasites in that phase of their life in which they are nourished and develop. When the nutritive activities cease by an arrest of the transformation of the hemoglobin into black pigment, and the reproductive phase begins, then quinine is ineffectual in its action.

With the development of organic chemistry new hope arose of synthetically building up specific remedies against malaria. All of these, however, that were claimed to be specifics, even if they had apparent antimalaric effect, proved to be far inferior to quinine and its derivatives. Only salvarsan, in certain cases of benign tertian infection and at the same time as a blood restituent, and methylene blue, in quartan fever, have been of value.

In 1907 Rabe(3) described the chemical constitution of the quinine molecule as consisting of one chinoline ring connected by a secondary alcoholic group with the so-called "loipon" portion; that is, the piperidine ring with two intermediate CH_2 radicals:



Giemsa(4) examined the therapeutic effects of many derivates. He found that only hydroquinin and quinethylin are superior to quinine and that any change in the bridge-carbon molecule necessarily lessens the antimalaric effect.

At the Tagung Deutscher Naturforscher und Aerzte, in Duesseldorf, September 22, 1926, the first announcement was made concerning "Plasmochin."

Schulemann, Schoenhoefer, Wingler, and Hoerlein(5) succeeded in preparing a chemical compound which they claim to be an

n-diethyl-amino-isopentyl-8-amino-6-methoxyquinolin, thus differing from quinine principally by lack of the "loipon" portion.

Some confusion has been created by calling this compound variously "beprochin," later on, "plasmochin," and now in English-speaking countries, "plasmoquine."

Roehl(5) found that this drug gave highly satisfactory results in canary birds infected with *Proteosoma praecox.* He administered 1 cubic centimeter of the solution for each 20 grams body weight and found the highest strength of quinine tolerated 1:200, the lowest effective 1:800; that is, the so-called chemotherapeutic index is 1 : 4. Roehl claimed to have found plasmoquine sixty times as effective as quinine with an index of about $\frac{1:1500}{1:50000}$ or 1 : 30.

Sioli(5, 6) experimented with the new antimalaric in forty cases of general paralysis therapeutically infected with tertian malaria. He showed that often with doses of 0.25 gram intoxications may occur; 0.15 gram daily was considered the upper limit. Sioli observed in one case after a total dosage of 0.6 gram in the course of eight days hepatic pain and cyanosis but without formation of methæmoglobin either in the blood or in the urine. Recovery was rapid, but the skin did not regain its natural color until three weeks later.

Muehlens(5, 7, 8, 9) treated one hundred seventy-two cases of naturally acquired human malaria with plasmoquine. These cases consisted not of first fevers but were all acute relapses or chronic cases. Muehlens notes that they had been treated under very favourable general conditions; that is, in a temperate climate (Hamburg), with sufficient food and rest in bed.

In benign tertian and quartan malaria this author found daily doses of from 0.05 to 0.1 gram, in a few cases even up to 0.15 gram, effective and stated that after the second or the third day of medication defervescence occurred and that parasites disappeared from the peripheral blood in five to seven days. He observed fewer relapses than after quinine treatment. Side reactions such as cyanosis of fingers, toes, lips, and face, and spasmodic gastralgia occurred now and then, the latter especially when plasmoquine was given on an empty stomach or in large individual doses of 0.05 gram. On the other hand none of the usual side effects after quinine medication such as bitter taste, deafness, tinnitus aureum, or dizziness was experienced.

In tertian and quartan infections plasmoquine is about as effective as quinine on both schizonts and gametocytes. However, Muehlens found in the treatment of æstivo-autumnal malaria that pure plasmoquine is not so efficient; he observed more relapses owing to its insufficient effect upon the subtertian schizonts. To prevent relapses quinine was added and the combination called "plasmoquine compound," which is now manufactured in tablets each containing 0.01 gram plasmoquine and 0.125 gram quinine sulphate. Formerly it had been manufactured in smaller tablets of 0.005 gram plasmoquine and 0.0625 gram quinine sulphate, which had been used for our experiment.

Muehlens states that—

> "For the first time we have found a medicament which causes the crescents to disappear within 4 to 7 days with the certainty of an experiment." He furthermore adds "that in acute infections of aestivo-autumnal malaria with many schizonts (rings ++++) and *without* gametes, plasmoquine treatment, immediately begun, nearly always prevented the formation of crescents."

The largest amount of plasmoquine he gave was 3.25 grams in sixty-eight days. He states that in none of his cases could gametocytes be found longer than seven days.

Muehlens's most interesting observation was the successful treatment of two cases of blackwater fever and of one case with petechiæ and ecchymosis in the skin and mucous membranes. The three cases were promptly cured by plasmoquine.

In a few cases he observed that crescents appeared, even after schizonts had disappeared, but these crescents disappeared very soon. In only one case the crescents, which appeared on the eighth day after the beginning of treatment and which had been discontinued just the day before, remained for a further seven days in the peripheral blood.

Muehlens reports that he observed no relapses among four cases of quartan infection, three relapses among forty benign tertian infections, and thirty-four relapses among forty-nine subtertian infections, after the administration of pure plasmoquine. He reports only four relapses in subtertian infection after plasmoquine-compound treatment and no failures in the tertian type. No severe symptoms of intoxication, even after daily dosage of 0.18 gram, were observed. Children and even babies tolerated the drug well.

Fischer(8) reports a prophylactic test with a ship's crew on the west coast of Africa. Thirty-nine members of the crew took, on three successive days of the week, 0.095 gram plasmo-

quine. He claims to have observed a morbidity of only 20 per cent for malaria compared with 25 to 30 per cent on other ships with quinine prophylaxis, 1 gram twice a week. Fischer means that the course of the disease was less severe, but he gave not only 0.055 gram plasmoquine and 0.5 gram quinine intramuscularly but later even quinine orally. For treatment Fischer thinks that plasmoquine was more willingly taken by the crew because it does not have the ill-effects of quinine.

In Talavera de la Reina, Spain, Roehl (8) treated successfully three tertian cases with pure plasmoquine, and three subtertian infections, but the latter remained all positive for parasites in the peripheral blood.

Schulemann and Memmi (8, 10, 11) treated over one hundred cases in Grosseto Hospital, Italy. Dosage: Three times 0.02 gram plasmoquine for seven days; four days interval; three times 0.02 gram plasmoquine, for three days; four days interval and so on for six weeks, if possible. Out of twenty-four tertian infections only one relapsed; four quartan infections, no relapse; insufficient effect on subtertian infections. With plasmoquine compound, three times 0.02 gram plasmoquine and 0.25 gram quinine daily, sixty-three cases of subtertian were treated. No parasites were found after the eighth day of medication. Thirteen cases relapsed during or after the intervals and between the medication days.

The authors mention the very interesting fact that changing from one medicament, be it plasmoquine or quinine, to the other, seems to act sometimes as a provocative, being followed by the appearance of parasites or fever. Two cases of blackwater fever were also cured with plasmoquine.

Side effects seldom occurred. Twice considerable cyanosis, once after three times 0.02 gram plasmoquine, the other after three times plasmoquine compound (0.02 plus 0.25), frequently slight livid bluish lips. Several times arrhythmia was observed. The authors mention especially having observed a marked lymphocytosis, in some cases up to 50 per cent. Gastralgia was rarely observed when plasmoquine was given on an empty stomach. Most of the complaints were psychotic, and "we frequently saw that this complaining of pains spread as an epidemic over one ward, while the other ward remained completely immune!"

Vomiting never occurred after plasmoquine and only twice after plasmoquine compound but stopped after continued medication of pure plasmoquine, therefore having been caused only

through quinine idiosyncrasy. The authors furthermore note and describe degeneration forms of adult parasites under plasmoquine treatment, as likewise occurs with quinine, but they observed such forms only in tertian infection. These forms show a complete, dark blue protoplasm with drop-shaped ramifications, partly cut off.

Mihajlo M. Radojicic(8) treated forty-nine cases of malaria in Skoplje, Jugoslavia, with pure plasmoquine. Nineteen cases were promptly cured after daily doses of 0.06 to 0.08 gram plasmoquine. "The parasites disappeared from the peripheral blood in 1 to 2 days and didn't reappear during further plasmoquine treatment." Seven cases of acute first subtertian fevers without crescents all remained free from gametocytes. Daily dose: Five times 0.02 gram plasmoquine. There were two relapses, one on the twentieth day after the beginning of treatment.

Ten cases had schizonts and crescents in the peripheral blood at the beginning of treatment. The author states that in these occurred "relapses much more frequently." Thirteen cases with only crescents gave the best results, the gametocytes all disappearing after five days. Gastralgia was never observed, cyanosis in only three cases.

A. Djokic and D. Stambuk(8) in Bitoly, Jugoslavia, treated one hundred two cases with plasmoquine. Generally 0.08 gram plasmoquine was given, the highest dose was 0.14 gram daily. In a very careful manner the authors divided the patients into several groups and gave them different combinations.

Gastralgia was seldom observed but cyanosis frequently. One case showed amaurosis, but this did not reappear when some days later plasmoquine again was given. Some statements might be quoted:

> Plasmoquine acted promptly upon tertian parasites (schizonts and gametocytes). Temperature dropped, splenomegaly was reduced, and the general condition improved rapidly. * * * We could not observe that in tertian infection plasmoquine reacts better upon new infections than upon relapses, nor is there any difference in its action on the sexual or asexual forms. Both forms are affected equally well and quickly.

In their cases the earliest time for the disappearance of parasites was one day and the longest five days. The authors conclude that in tertian infection pure plasmoquine may well replace quinine and is even superior to quinine in the quartan type. In subtertian infection the authors confirm Muehlens's observations of the insufficient effect of pure plasmoquine on

small rings, but the absolutely certain destruction of crescents, and the good effect of combined plasmoquine and quinine administration on both types. They also note that, especially on small rings, plasmoquine has somewhat of a provocative action, as already mentioned by Schulemann and Memmi.

Finally Djokic and Stambuk again direct attention to the outlook from an epidemiological standpoint in so far as "plasmoquinization" cuts the vicious circle of malarial transmission in crescent carriers.

G. Polychroniades (8) treated one hundred eighty-eight cases in Saloniki. Four tertian, two quartan, and thirty-eight subtertian cases were given plasmoquine, three times 0.02 gram daily. There were nineteen relapses in the subtertian form with nine cases showing persistently small rings. All tertian and quartan infections were cured. Eight cases showed cyanosis and eight gastralgia. Three quartan and one hundred thirty-nine subtertian cases were given plasmoquine compound (0.02 plasmoquine and 0.25 quinine) three times daily. In all cases the gametocytes disappeared rapidly between the second and the eighth day after treatment began. Small rings, however, disappeared between the second and the tenth day, but reappeared in fifteen cases, between the seventh and the twenty-third day. Twenty-two cases had abdominal pains, two showed cyanosis.

The author reports three blackwater cases cured by plasmoquine. The first, tertian infection, showed hæmoglobinuria with fever. After three days treatment (0.06 gram daily) parasites disappeared and the urine became normal without hæmoglobin (reaction of Rolland and Mayer). The temperature fell to normal on the sixth day. On the fourteenth, rings appeared again without either rise of temperature or hæmoglobinuria. Then plasmoquine compound was given. The parasites disappeared again but reappeared on the twenty-second day. Then 1 gram bichloride of quinine was given by mouth with the effect that the urine again became black for twenty-four hours. After one day interval plasmoquine compound was given for three days, this was repeated after five days interval. Parasites as well as hæmoglobinuria disappeared. Later quinine was again tried in increasing doses and tolerated up to 0.75 gram.

The second case had only fever which persisted for fifteen days. Hæmoglobinuria disappeared after twenty-four hours. On the twenty-first day tertian rings were found in the pe-

ripheral blood without fever. After administration of plasmoquine compound the parasites disappeared finally and no hæmoglobinuria occurred.

The third case (type not mentioned) had neither fever nor parasites in the peripheral blood. Only symptomatic treatment was given and hæmoglobinuria disappeared after twenty-four hours. On the eleventh day rings (type not mentioned) appeared, but without rise of temperature. After administration of plasmoquine compound the parasites disappeared rapidly and no hæmoglobinuria occurred. The author concludes:

> Notwithstanding minor side-effects, unimportant, like cyanosis of lips and nails, gastralgia, but not frequently (23 per cent), there is no contraindication to plasmoquine, and this includes even hæmoglobinuria and pregnancy. On the contrary according to our experiences, in certain of such cases it is quinine that would be contraindicated.

M. Sliwensky(8) treated in Burgas, Bulgaria, two hundred twenty-five cases of malaria in the hospital and fifty-nine ambulant. The author reports the usual good effect in the tertian and quartan types. Of eight quartan infections there was no relapse; among twenty-six tertian hospital cases one relapsed forty days after treatment with two times 0.04 gram plasmoquine for only five days; a second case relapsed after sixteen days, he had received the same dose (two times 0.04 gram plasmoquine) for seventeen days. This was obviously an inefficiently low dosage.

A third relapse occurred after twenty-one days in a patient who received plasmoquine compound (0.03 gram plasmoquine and 0.375 gram quinine sulphate) two times daily for eleven days. Among the eighteen ambulant tertian infections only one relapse was observed after eighty days; the dosage had been two times 0.02 gram plasmoquine for eight days.

Among one hundred twenty-five subtertian cases that were given plasmoquine compound (0.03 gram plasmoquine and 0.375 gram quinine sulphate) twice a day for five to twelve days, thirty-eight relapses occurred.

> In only a very few cases could crescents be found after eight days. In only one case after a sea-bath and during plasmoquine treatment could we observe a few crescents on the seventeenth day.

As a whole, plasmoquine compound was found by the author much superior to pure quinine medication on account of its certain effect on crescents.

Two cases of quinine idiosyncrasy with epistaxis and one case of blackwater fever tolerated plasmoquine well and were cured. The blackwater patient, female, 40 years old, with subtertian infection for about two months, had taken quinine. After 0.4 gram quinine a very severe attack of blackwater fever occurred with icterus, vomiting, coma, urine dark reddish brown. Under symptomatic treatment and plasmoquine, beginning with twice 0.01 to 0.05 gram, the patient improved quickly and tolerated quinine later on.

The author directs attention to two facts; namely, that babies, 3 to 14 months old, tolerate plasmoquine very well even in doses five times as large as adults, and, second, that even enormous enlargements of the spleen decrease very rapidly.

Cyanosis and gastralgia were only occasionally observed.

S. Manaloff-Sliven(12) reports ten cases from Bulgaria. One tertian case received six tablets of plasmoquine compound (six times 0.02 gram plasmoquine and 0.1 gram quinine sulphate) daily and became negative for parasites after four days.

Two patients with quartan infections had taken quinine for a longer period but still showed larger numbers of parasites. Both became negative for parasites on the fourth day; daily dosage 0.08 and 0.1 gram plasmoquine, respectively.

Each of seven patients with subtertian infections was given 0.06 gram plasmoquine. The author does not state why he treated tertian infections with plasmoquine compound and æstivo-autumnal infections with pure plasmoquine; it is no wonder that in these seven cases no sufficient action was observed and, besides, four relapses were noted. Cyanosis occurred only in one case.

M. Sliwensky,(13) in Sofia, Bulgaria, reports a very instructive observation which he calls: "Plasmoquine for controlling gametocytes from an epidemiological standpoint. (Der Gametenversuch mit Plasmochin in epidemiologischer Betrachtung.)"

In a distant village, Vajakeny, eighty-one carriers of gametocytes were treated and received 0.075 to 0.08 gram plasmoquine daily in one dose after dinner. He was able to treat sixty-four of the eighty-one for six days. Blood films were taken one day after treatment was finished, fifty days later and, for the third time, after four months.

All carriers who showed at the beginning only gametocytes (tertian 3, subtertian 18) remained free after four months.

Relapses after fifty days: Six of sixteen carriers with subtertian schizonts and gametocytes, two of twenty-two who had shown before only schizonts, one of two with tertian schizonts and gametocytes, and one relapse after four months in a patient with double infection (tertian and subtertian).

Cyanosis or gastralgia was never observed although the whole, comparatively high, dose of plasmoquine was administered at once.

The author concludes:

> 0.00125 gram plasmoquine per kilogram of body weight, in the form of plasmoquine compound for five to six days, is able to free the peripheral blood of crescent carriers of the three types for at least four months. Especially in countries with marked so-called "seasonal-malaria," this fact should be made use of as a most efficient and economic measure. It is possible to give at once the whole daily dose of 0.06–0.08 gram plasmoquine without any ill effect.

Baermann and Smits(14) stated that in their experiments with eleven tertian and one quartan case there were the usual good effects of plasmoquine (four times 0.02 gram); no relapses in eighty days. With plasmoquine compound, however, one of three tertian cases relapsed in fifty days.

The authors even gave pure plasmoquine to nine subtertian infections, and it is no wonder they had five relapses. It is notable in this experiment that among seven cases without crescents even under plasmoquine treatment crescents appeared in four cases. Furthermore, eight relapses were treated with plasmoquine compound (0.01 gram plasmoquine and 0.125 gram quinine sulphate four times a day). Six remained free, while in the blood of one case after fourteen days treatment schizonts as well as crescents remained demonstrable. The other case died.

> Weight 48.4 kilograms, hæmoglobin 70, pulse 68. Spleen one finger breadth, no albumin, one subtertian ring in four fields. Treatment, plasmochin 0.02 gram, four times daily. On the third day he had some cyanosis, became unconscious, temperature 39.2° C. (102.55° F.), leucocytes 16,000, albumin without casts. He was given quinine intravenously and intramuscularly with disappearance of parasites from the circulation, but he died next day with a rapid fall of temperature and with a crescent in the blood. No malaria parasites were found except some crescents in the spleen. The liver showed patchy, fresh, and very silght necrosis.

Plehn(15) reports a quinine-resistant strain of æstivo-autumnal type in the case of a sailor who was infected in Karachi. This man received large doses of different medicaments, including "beprochin," and still developed schizonts as well as gametocytes but finally was cured.

In various hospitals of the United Fruit Company(16) in Central America one hundred ninety-four cases of malaria were likewise treated with plasmoquine and plasmoquine compound. Cortes from Preston, Cuba, Brosius from Almirante, Panama, Macphail from Quirigua, Guatemala, and Nutter from Tela, Honduras, agree with Muehlens in their favorable reports; but Whitaker, who had only pure plasmoquine without quinine, reports from the same hospital in Tela that, besides the well-known insufficient effect of pure plasmoquine in æstivo-autumnal infection, even three cases of tertian and one of quartan infection after 0.08 to 0.1 gram for four to six days remained positive for parasites, although the fever was controlled just as well as with quinine. One death occurred in Preston, and the report is quoted in full on account of its importance.

The patient was a male negro, 35 years of age. He was admitted suffering from a severe attack of aestivo-autumnal malaria and was treated with the new drug, plasmochin compound. On the 4th day of his treatment, after the fever had disappeared and the blood film was negative for malarial parasites, he developed a profound anaemia, leucocytosis, jaundice, nausea (vomiting), and somnolence. The urine was negative for haemoglobinuria. He died within 48 hours after the onset of this sudden attack. The toxic influence of plasmochin compound was suspected to have played an important rôle in the cause of death.

MICROSCOPIC EXAMINATIONS BY DR. F. B. MALLORY (U. F. A. 75)

Heart.—Negative.

Spleen.—Numerous lymphocytes and plasma cells in the pulp; many endothelial leucocytes in the blood sinuses containing red blood corpuscles, often in great numbers (10 to 20 and more). Malarial pigment occurred occasionally in the red blood corpuscles both free and in phagocytes.

Liver.—Endothelial cells lining sinusoids were prominent, occasionally phagocytic, and some contained pigment. Some of the liver cells in the centers of the lobules contained vacuoles in which were dots and occasionally threads of fibrin (hydropic degeneration). Rarely a liver cell was necrotic and was being invaded by endothelial leucocytes. There was slight lymphatic infiltration of periportal connective tissue.

Kidney.—Moderate oedema of the tubules.

Cerebrum.—Negative.

MICROSCOPIC DIAGNOSES

Malarial infection of the spleen.
Marked phagocytosis of red blood corpuscles in the spleen.
Early stage of central necrosis of the liver.

REMARKS

It is unfortunate that no bone marrow was included with the other tissues. The anaemia may have been due to destruction of red blood corpuscles by the malarial infection. The phagocytosis in the spleen would seem to indicate this. The beginning necrosis of the liver cells is probably due to the toxic action of the plasmochin, but it is not nearly so active as chloroform or carbon tetrachloride. Possibly plasmochin has a destructive effect on the red blood corpuscles.

The other patient in Preston hospital developed mild symptoms of jaundice and decrease of hæmoglobin under a daily dose of 1 gram quinine and 0.08 gram plasmoquine (that is, 16 tablets) but recovered.

Observation of side effects, such as cyanosis, nausea, and abdominal pains, differs widely in the different hospitals and might partly depend on the individuality of the observers. In this respect we refer to Memmi and Schulemann's description of the epidemic spreading of complaints over a ward. Whereas in Tela Hospital eleven of fifty-four patients under pure plasmoquine treatment showed cyanosis or epigastric pains and two of twenty-eight under plasmoquine compound treatment felt "slight nausea," only four of one hundred eleven patients from the three other hospitals had any complaint at all. Besides, Whitaker from Tela Railroad Hospital observed these ill effects only after administration of 0.1 gram and adds that after reduction to 0.08 gram plasmoquine "these results were infrequent."

One case with malarial infection and insufficient quinine treatment may be quoted. This, under 0.06 gram plasmoquine and 0.75 gram quinine daily, develop icterus and slight hæmoglobinuria on the fifth day, but they disappeared after twenty-four hours without interruption of the medication. In general the experience in the four hospitals of the United Fruit Company confirms to a large degree the statements of Muehlens concerning clinical symptoms and parasiticidal action. The reports note especially rapid reduction in size of the spleen after administration of either plasmoquine or plasmoquine compound and indicate a very important field of usefulness in pregnancy, even in its late stage where no such

uterine contractions occurred after plasmoquine compound as are observed frequently under pure quinine medication.[2]

Philip Manson-Bahr (17, 18) reports twenty-eight cases. He confirms the good effect of plasmoquine in ten tertian cases and the well-known insufficient effect in the subtertian type. His results with plasmoquine compound were satisfactory in five cases of æstivo-autumnal type and even in five cases of benign tertian. He observed several toxic side effects, three cases showed methemoglobinuria (in two of them the chocolate-brown blood contained methemoglobin) within twenty-four hours of the "cyanosis" after 0.4 gram plasmoquine. The daily dosage was 0.12 gram. These two patients had a typical hæmolitic icterus. Manson-Bahr says: "The attack resembled a mild blackwater-fever which ran a favorable course."

Cherefeddin (19) reports from Gureba-Institute, Constantinople, three cases of subtertian infection which were cured by pure plasmoquine. He is the only author who claims pure plasmoquine superior to quinine against subtertian schizonts. He says: "The action of plasmoquine upon the rings of æstivo-autumnal type is stronger than that of quinine; it acts certain and well on subtertian gametocytes."

Eiselsberg (20) reports a poisoning on the fifth day of plasmoquine medication. The daily dose was far under the permitted dose of 0.15 gram, the total dosage was 0.2 gram. The patient had no malaria but a very chronic pempigus conjunctivæ. He became—

By that time (2nd December) yellow, weak with much epigastric pain and, after the last pill, vomited and lost consciousness. His tempera-

[2] After this paper had been finished (January, 1928), the 16th Annual Report of the United Fruit Company (1927) had been published, which confirms as a whole the very satisfying experience with plasmoquine as published in the 15th Annual Report. It seems, however, that the physicians of the company observed occasionally some toxic side effects, which made them decrease the amount of plasmoquine to 0.04 gram in combination with from 1 to 3 grams quinine daily. We consider this amount of plasmoquine too small, and we think that such heroic doses of quinine are in excess and that they give no better results than smaller doses, which in acute cases with alarming symptoms may be given intramuscularly.

An outstanding observation was made by Barber and Komp. They found that small doses of plasmoquine may so cripple gametocytes that they are rendered incapable of forming healthy oöcysts. By this toxic action upon the crescents, mosquitoes feeding on these inviduals do not become infected. Deeks says: "This observation is exceedingly important, and if it is confirmed, plasmoquine must be considered of paramount importance in malaria control."

ture was 39.6 (103.3) and the urine deep brown. He came under the care of Eiselsberg next day. He was still vomiting but not bringing up blood. Urine dark brown with brown sediment and giving guaïacum test, even when diluted 500 times; much albumin; red corpuscles; an occasional leucocyte; no casts: Liver very tender; spleen two fingers. Red corpuscles 2,400,000 with poikilocytosis and anisocytosis. By 6 p. m. the red corpuscles numbered 1,550,000; the serum was brownish red with a strong direct bilirubin reaction and with urobilin strongly positive. Blood transfusion and dextrose improved matters. On the fourth of December the red blood corpuscles numbered 1,300,000, the whites 15,700; on the fifth methemoglobin was spectroscopically established in the urine, apparently the first spectroscopic examination made. Rapid improvement followed.

G. Carmichael Low(21) in a short note writes against plasmoquine and without mentioning his results reports four cases. In three of them he observed "cyanosis" and of the fourth reports "sickness after the use of plasmoquine," but he does not give any further details.

W. Fletcher and K. Kanagarayer(22) report ninety-seven cases of malaria treated with plasmoquine. The authors state that the effect in tertian and quartan type "upon the parasites was equally striking," and that "plasmoquine proved at least equal to quinine." In subtertian fever they observed, as is sufficiently known, not a satisfactory action with the pure plasmoquine, but had to employ plasmoquine compound. Concerning side effects the authors mention only two cases with cyanosis, one with gastralgia, and two with fever and collapse while undergoing treatment but without any abnormal findings in the urine, so that the authors do not consider this illness due to plasmoquine.

Recently, P. Ignacio(23) published a very interesting paper on the plasmoquine treatment of twenty-nine cases of malaria, most of them in the Philippine General Hospital, Manila. This work was done long after we had started our studies and was under the direction of the Research Committee of the College of Medicine, Manila. Briefly it may be noted that the author saw the well-known effects reported by Muehlens, when the drug was administered properly. Unfortunately, the author had not a sufficient supply of plasmoquine compound, so that "we have used a combination of plasmoquine tablets and quinine bisulphate capsules." For blood examinations, no thick films were made, but "thin smears obtained one half to one hour after the injection (adrenalin or strychnine) were always used in the blood examination using the Wright's stain."

Side effects were observed as usual, but "the untoward effects are, therefore, few and mild and that they disappeared promptly when the drug is withheld." The author, following Muehlens, says of plasmoquine compound: "It appears that plasmoquine compound is more powerful than quinine."

Pharmacological tests were made by Eichholtz[8] and Le Haix and De Lind van Wyngaarden.[24] Eichholtz found that in cats 2.5 to 5 milligrams plasmoquine per kilogram weight, given hypodermically, produces methaemoglobin formation. Then he states:

1. Intravenous injection of plasmoquine affects in cats, dogs and rabbits the coördinate action of the heart by suppressing systoles or duplicating them, producing arrhythmia perpetua in higher doses.
2. Adrenalin, in small amount, prevents this interruption. The amount of adrenalin which is formed and flows into the blood after psychic emotion or muscular activity acts in like degree.
3. Quinine, given in sufficient dose (i. e. 2 to 4 milligrams intravenously), also counteracts.

Le Haix and De Lind van Wyngaarden showed that considerable differences prevail in the different animals. Whereas per kilogram weight the fatal dosage for cats is 5 milligrams, given either hypodermically or intravenously, and 7.5 milligrams if given orally, rabbits may die after the administration of only 3.5 milligrams, but tolerate up to 20 milligrams given hypodermically, and even 225 milligrams if given by oral application. Cats seemed to recover more quickly than rabbits after poisoning. Death occurs with symptoms of dyspnœa, asphyxia, bradycardia, and arrhythmia. The authors note specially the formation of methæmoglobin.

Plasmoquine can be identified[25] after medication in the urine by extracting the urine (200 to 300 cubic centimeters) after alkalization with ether. After adding 2 per cent acetic acid the ether is evaporated. The residue is taken up with glacial acetic acid and tetra-chlor-benzoquinone, so-called chloranil:

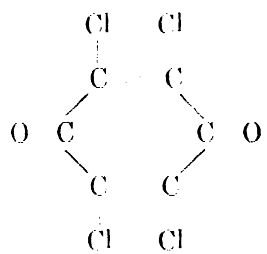


TABLE 7.—*Records of additional cases.*

No.	Name.	Type of parasite.	Medication.	Days after treatment. 1	2	3	4	5	6	7	8	9	10	11	12	13
1	Mr. A	E	5×2											[illegible]		
2	Mrs. A	E	5×2										[illegible]			
3	Baby A. 9 months old	E	3×1								[illegible]					
4	B	[illegible] E	6×2			[illegible]		[illegible]								
5	H. Ch	T [illegible]	6×0.02	[illegible]												[illegible]

BLOOD-PICTURES OF CASE 5.

		1	2	3	4	5
Number of leucocytes	7,200				7,900	6,000
Promyelocytes	—	2	—	—	—	—
Myelocytes	—	1	—	2	1	—
Youthly nonlobulated	2	2	—	—	—	½
Nonlobulated polymorphonuclears	12	7	—	5	3	2½
Lobulated polymorphonuclears	48	37	—	43	441	42
Eosinophiles	2	1	—	2	5	7
Lymphocytes	25	35	—	43	43	44
Monocytes	11	15	—	5	4	4
Basophiles	—	—	—	—	—	—

A bluish-green or bluish color appears, according to the concentration.

Plasmoquine containing urine gives a precipitate with mercury iodide-potassium iodide, as does quinine, but which persists in heating.

Plasmoquine, on the other hand, does not give the thalleioquin reaction, which remains characteristic for quinine.

The diazo reaction is positive for plasmoquine in dilutions of 1 : 100000.

Our own experience with plasmoquine includes ninety cases of authochton-acquired malaria.[3] Some were private patients, but the majority were cases in San Lazaro Hospital, Manila. Most of the latter patients came from Novaliches district, Rizal Province, about 25 kilometers north of Manila, Luzon, where a new water-supply system for Manila is under construction. The blood films of the private cases were all stained with Giemsa's stain, examined and checked by the two authors separately. From the hospital cases, however, the blood films were taken by one of the resident physicians (Dr. J. Salta or Dr. B. Barrera), stained in the beginning with Wright's stain and latter with Giemsa's stain also, the latter being by far the better method. Another thick blood film and, if necessary, a thin smear too, was stained and examined by the authors themselves. Both findings were checked and usually agreed. In the very rare cases of nonagreement they were considered as positive.

Thirty-nine pure tertian infections were treated with plasmoquine as a shown in Table 1 and 4. The daily dosage was 0.02 gram plasmoquine three times, which was given without interval

[3] After this paper had been already finished (January, 1928), we had the opportunity to treat five more cases of malaria with plasmoquine. As Table 7 shows, the same good effects of plasmoquine medication were obtained in one pure tertian and four subtertian infections. Of the latter one was a baby, 9 months old, which got three times one tablet plasmoquine compound (0.005 gram plasmoquine and 0.0625 gram quinine sulphate) a day and tolerated it well. The blood picture of the tertian case was followed up and is also shown in Table 7. In this case the lymphocytosis after plasmoquine medication is pronounced as well as the appearance of a few very young forms of leucocytes; namely, myelocytes and even promylocytes. We do not decide if this answering on behalf of the bone marrow and the spleen is to be considered as a precipitated regeneration caused by the malarial infection or by the toxic effect of the drug.

TABLE 1.—*Tertian type of malaria treated with plasmoquine.*

[○, schizonts; ⊛, merozoites; ⊕, gametocytes; !, abundant; ⁝, change in the medication; ||, end of treatment.]

No.	Name.	Type of parasite.	Daily dose.	Days after treatment. 1	2	3	4	5	6	7	8
			g.								
1	M. M	○	0.12	○	......	......	○	......	—	......	—
2	R. G	○	0.12	○	......	......	○	......	—	......	—
3	S. M	○	0.12	○	......	—	......	......	—	......	—
4	P. C	○	0.12	......	○ ⊛ !	......	......	○	......	—	......
5	C. V	⊛ !	0.12	......	⊕ ⊛ !	......	⊕ ○	......	......	—	......
6	M. C	○	0.12	......	......	○	......	—	......	—	......
7	A. C	○	0.12	......	—	......	......	—	......	—	......
8	M. L	○	0.12	......	......	○ ⊕	......	—	......	—	......
9	A. N	○	0.12	......	○	......	—	......	......	—	......
10	B. G	○	0.12	......	—	......	—	......	......	—	......
11	M. S	○	0.12	......	—	......	—	......	......	—	||
12	C. Ve	○	0.12	......	—	......	......	—	||	......	......
13	J. L	○	0.12	......	—	......	—	......	—	......	— ||
14	F. H	○	0.12	......	—	......	......	—	......	—	||
15	M. B	○	0.24	......	......	......	○	......	—	......	......
16	M. N	○	0.24	......	—	......	—	......	—	||	......
17	A. A	○	0.24	......	○	......	—	......	—	......	......
18	A. Ri	○ ⊛ ⊕ !	0.24	......	○ ⊕	......	—	......	—	......	—
19	M. Lu	○ ⊕	0.24	......	......	○	......	—	......	......	—
20	F. R	○	0.12	......	○ ⊕ ⊛ !	0.24	—	......	—	......	—
21	A. M	○	0.12	......	○ ⊕ ⊛ !	0.24	—	......	—	......	—
22	A. P	○ ⊕	0.24	......	○ ⊕	......	—	......	—	......	—
23	J. D	⊕ ⊛ !	0.24	......	○	......	—	......	—	0.12	—
24	P. V	○	0.24	......	○	......	—	......	—	0.12	— ||

25	J. Ca.	○÷	0.32		○÷	0.12		—		—
26	J. Ma.	○÷	0.12	○÷		—		—		—
27	d. l. R.	○	0.12	—		—		—	‖	
28	S. J.	○	0.12	○÷		÷		—		—
29	F. Di.	○÷⊛!	0.12	○		—		—		—
30	F. Sa.	÷⊛!	0.12		—		—		—	
31	N. Du.	○÷	0.12		—		—		—‖	
32	F. Po.	○÷	0.12	○÷		—		—‖		
33	J. Me.	÷	0.12	—		—				
31	Ag.	÷⊛!	0.12	○÷				—		—

No.	Name.	Days after treatment.												
		9	10	11	12	13	14	15	16	17	18	19	20	21
1	M. M.			—‖										
2	R. G.	‖												
3	S. M.		—‖											
4	P. C.	—	‖											
5	C. V.	—			—		—‖							
6	M. C.	—‖												
7	A. C.	—‖												
8	M. L.	—	‖											
9	A. N.	—	‖											
10	B. G.													
11	M. S.													
12	C. Ve.													
13	J. L.													
14	F. H.													
15	M. B.	—	‖											
16	M. N.													
17	A. A.	‖												

TABLE 1.—*Tertian type of malaria treated with plasmoquine*—Continued.

No.	Name.	Days after treatment.												
		9	10	11	12	13	14	15	16	17	18	19	20	21
18	A. Ri	||												
19	M. Lu		—	||										
20	F. R.	||												
21	A. M	||												
22	A. P.	||												
23	J. D.							+0.12		[illegible]		—		—
24	P. V.													
25	J. Ca		—	||										
26	J. Ma		— ||											
27	d. l. R													
28	S. J.		—		—		—							
29	F. Di	||												
30	F. Sa													
31	N. Du													
32	F. Po													
33	J. Me													
34	Ag		—	(a)	(a)	(a)	(a)	—						

[a] Without medication.

TABLE 2.—*Aestivo-autumnal type of malaria treated with plasmoquine.*

[○, schizonts; ⁂, merozoits;), crescents; !, abundant; —, change in the medication; ‖, end of treatment.]

No.	Name.	Type of parasite.	Daily dose.	Days after treatment. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	F. A.	○	3×2	○	○)			○		○		—		—		— ‖							
2	T. C.	)	3×2			○		○		○		)		—		—		—		—	‖		
3	G. P.	○)	3×2			—		—		—			—	‖									
4	K. M.	○	3×2				○		—		—		—		— ‖								
5	A. R.	○	3×2			○		○			—	—		— ‖									
6	M. d. G.	○)	3×2			○)		○		—		—		— ‖									
7	J. T.	○	3×2		○			○		○		○			—		—		—			— ‖	
8	V. R.	) !	3×2			)		○		—		—		—	‖								
9	V. G.	○	3×2			○		—		—		—			—		— ‖						
10	E. V.	○	3×2			○)		○		—		—		—	—	‖							
11	A. Ro	○ !	3×2		○ !			—		—		—		‖									
12	R. P.	○	3×2			○		—		—		—	‖										
13	G. P.	○	3×2			)	○)		—		○		○		—			—	‖				
14	M. F.	○ !	3×4		○			—		—			— ‖										
15	V. Z.	○	3×4			○		—		—		—		—	‖								
16	M. J.	○	3×4		○		—		—		—		—	‖									
17	G. G.	○	3×4			—			—			—	‖										
18	A. P.	○)	4×4		—		—		—		—												
19	B. A.	○	4×3		—		—		—		—		—		— ‖								
20	T. M.	○	4×4		○		—		—		—	‖											
21	E. M.	○ !	4×5		○ !		○		—	3×2	—		—	‖									
22	E. Ta	○) ⁂	3×2		○		—		—		— ‖												
23	A. Ra	○	3×2		○		—		—														
24	J. K.	○	3×2		—		—																
25	B. B.	○)	3×2		—		—		—	(a)	—		—			‖							
26	F. Schn.	○ !		○ !	○ !	○ !		○	—	—	—		(b)										

a Without medication.

b For daily dosage, see Table 7.

up to the day of discharge from the hospital, the longest period being fourteen days. Whereas in most patients the tertian parasites can no longer be found on the fourth day after the beginning of treatment, and have already disappeared even on the second day in some cases, in a few cases the peripheral blood is not found free before the sixth or seventh day. With the exception of these rare cases we can confirm Muehlens's first report. But, on the other hand, and as will be explained later, we do not consider pure plasmoquine as a convenient antimalaric for tertian infections unless one is working in one of the rare districts of the world where only tertian fever prevails and neither æstivo-autumnal nor double infections occur.

Defervescence occurs early.

We have had no opportunity to treat quartan infections, and this type is extremely rare in the Philippines.

We treated twenty-seven cases of simple subtertian infection with plasmoquine compound as is shown in Table 2. The daily dosage was two tablets three times in the beginning; that is, 0.03 gram plasmoquine and 0.375 gram quinine sulphate. Later, for case 14, we increased the amount to four tablets three times a day; that is, 0.06 gram plasmoquine and 0.75 gram quinine sulphate. The quantity was doubled because in a few cases of double infection (tertian and æstivo-autumnal type) the parasites persisted in the peripheral blood to the twenty-second and even to the twenty-fifth day after plasmoquine medication was begun and continued daily *without interruption* (see case 14, Table 3).

Special interest attaches to case 26, for this was the most carefully observed patient in the group (one of the private patients of Dr. H.). Daily blood examinations were made. Later, after discharge from the hospital, the patient carelessly took too small an amount of plasmoquine compound and came back after four weeks not only with fever, loss of fifteen pounds, and headache, but also with a few crescents in the thick blood film. Crescents had never been found before.

As Table 2 shows, subtertian parasites were found in our cases longer than Muehlens states in his experiences. With a dosage of two tablets three times, whereas crescents disappeared very soon and could not be found after the fourth day of administration, schizonts persisted until the ninth and even the tenth day (case 13, G. P.). It might be stated that crescents appeared in three cases on the second and the third day after treatment began, where they had not been observed before.

This somewhat "provocative" effect of the drug will be discussed later.

Interesting observations were made in our eighteen cases with double infection as shown in Table 3.

Whereas these cases revealed all the difficulties in making an exact differential diagnosis between tertian and subtertian young schizonts (small rings) in the thick blood film, in all these cases examinations of thin smears were necessary for the existence of Schueffner dots, and enlargement or reduction in size and darker coloration, respectively, of erythrocytes, and for finer structure of the parasite's protoplasm.

Cases 1, 4, 5, and 13 showed only tertian schizonts in the first blood film examined. Cases 1 and 4 received two tablets of pure plasmoquine three times a day (0.12 gram daily). Case 1 showed on the second day small subtertian rings. On the fourth day crescents appeared, but disappeared three days later after plasmoquine compound (two tablets three times a day) was administered. In case 4 crescents appeared on the sixth day after treatment with pure plasmoquine had begun and two previous blood examinations were found negative for any parasites. The day after administration of plasmoquine compound the crescents were found no more.

Case 5 received four tablets of pure plasmoquine three times a day (10.24 grams) and showed small subtertian rings in abundance two days later. After daily administration of four tablets three times a day of plasmoquine compound these subtertian rings remained for five days more.

Case 13 with tertian rings received 0.12 gram pure plasmoquine daily. On the eleventh and the twelfth day after the beginning of treatment the blood examination was negative. On the fifteenth small subtertian rings appeared and were abundant on the seventeenth day. Plasmoquine compound, two tablets three times a day, was given, and seven days later the peripheral blood was free.

Cases 3, 6, and 15 showed subtertian rings. After administration of plasmoquine compound, two tablets three times a day, case 3 revealed on the third day tertian schizonts, which were found together with subtertian rings. He left the hospital one day later.

Case 6 showed tertian schizonts together with subtertian two days after treatment with plasmoquine compound was begun. Two days later the peripheral blood was found negative for both types of parasites and remained so.

TABLE 3.—*Double malarial infections treated with plasmoquine.*

[○, schizonts; ⊕, merozoits; ÷, gametocytes;), crescents; !, abundant; ..., change in the medication; ||, end of treatment; E, æstivo-autumnal; T, tertian.]

No.	Name.	Type of parasite.	Daily dose.	Days after treatment. 1	2	3	4	5	6	7
1	de V	T	0.12		○ E		E)	3×2 ...		—
2	A. L.	○ T E	3×2		E			—		
3	J. R.	E	3×2	...		○ T E	||			
4	F. P.	T	0.12		—		—		)	
5	E. P.	T !	0.24		E !		3×4	E !		
6	D. D.	E	3×2		○ T E		—		—	...
7	D. J.	T E	3×4	...				—	...	...
8	A. F.	T ÷ E	4×4		—		—		—	...
9	D. M.	T E	4×4		— ||	...				
10	J. O.	T E	4×4		T ÷ ○ E	...	—		—	
11	de J	T E	4×4		E	3×3	—		—	
12	L. d. C.	○ E ⊕) ! T ÷ !	3×4	...	○ E ÷ ○ T	...	—	...	—	...

No.	Name.	Type of parasite.	Daily dose.	3	7	9	11	12	15	17
13	J. D.	T	0.12	T	T	T	—	—	E?	E

No.	Name.	Type of parasite.	Daily dose.	3	5	7	9	12	14	16
14	M. R.	T E	3×2	T E	T E	T E	E	E!	E!	E

No.	Name.	Type of parasite.	Daily dose.	2	3	4	6	8	10	13
15	M. D.	E	3×2	T	0.12	—	—	—	E	3×2 E

TABLE 3.—*Double malarial infections treated with plasmoquine*—Continued.

No.	Name.	Days after treatment. 8	9	10	11	12	13	14	15	16	17
1	de V		—		—			—		‖	
2	A. L.	—	‖								
3	J. R.										
4	F. P.	◑	ǀ 3×2	—		—		—		—	‖
5	E. P.	○		—		—			— ‖		
6	D. D.		— ‖								
7	D. J.	— ‖									
8	A. F.										
9	D. M.										
10	J. O.	—									
11	de J.	—		—	‖						
12	L. d. C.	—		— ‖							

No.	Name.	18	20	22	24	27	29	31			
13	J. D.	ǀ 3×2	○ E	○ E	—	—	—	— ‖			

No.	Name.	18	20	22	25	27	29	31	33	35	
14	M. R.	E	E	E	E	—	3×4	—	—	— ||	

No.	Name.	15	17	20	22	25	28	30	32		
15	M. D.	E	E	E	E	3×4 —	—	—	— ||		

In case 15 only tertian schizonts were observed on the second day. The following day 0.12 gram pure plasmoquine was given and continued daily. The blood examination was negative until the tenth day after treatment was originally begun, when subtertian rings reappeared. Three days later plasmoquine compound, two tablets three times a day, was given. The parasites were still present on the twenty-second day. Though the blood examination was negative on the twenty-fifth day, the dosage of plasmoquine compound was doubled (four tablets three times a day), and the peripheral blood remained free.

Cases 2, 7, 9, 10, and 11 showed both young schizonts of tertian as well as of the subtertian type. The parasites had already disappeared in case 7 by the third day.

In case 2 only subtertian rings were found on the second day and had disappeared by the time of the next examination, the fifth day.

In case 11 there were present, besides the tertian and the subtertian schizonts on the second examination, also tertian gametocytes; these had already disappeared by the third examination two days afterwards.

Case 8 showed tertian and gametocytes and schizonts besides æstivo-autumnal schizonts in the first-examined blood film; they disappeared very quickly and could not be found two days afterwards or subsequently.

Case 12 was an exceptionally heavy infection with abundant tertian and subtertian parasites of each stage, gametocytes as well as crescents included. On the second day crescents had disappeared, and there remained only a few tertian gametocytes besides both types of rings. The thick film on the fourth day was negative and further blood pictures remained the same.

Case 14 showed small rings of both types. He received two tablets three times a day. On the ninth day the tertian parasites had disappeared, but increased numbers of subtertian rings were observed during the two following examinations. These young subtertian schizonts were, however, found in decreasing numbers until the twenty-fifth day. Though two days later the blood examination was for the first time negative, the medication was doubled and the peripheral blood remained free.

In two of the three cases in this table where the peripheral blood remained positive for parasites over a longer period it is remarkable that previous medication of pure plasmoquine for some days had been given. Discussion might be raised as to

how far a certain "accustoming" of the parasites may be responsible for this fact.

Table 4 shows six cases which erroneously received quinine after originally plasmoquine treatment was begun.

Cases 2, 3, 4, and 5 with simple tertian infections received 0.12 gram pure plasmoquine daily. The peripheral blood was found free of parasites in two cases on the third day, in one on the fourth, and in one on the seventh day after treatment began.

In case 1 only tertian schizonts, merozoites, and gametocytes were found. On the ninth day small subtertian rings were observed in the absence of tertian forms.

Case 6 showed tertian rings. The second day after the beginning of treatment only small subtertian rings were found. The fifth day not only these small rings remained but crescents also appeared under pure plasmoquine administration. The following day plasmoquine compound was given. Though crescents were no longer found, the small rings persisted until the tenth day. This observation reminds us of cases 13 and 15, of Table 3, where likewise *pure plasmoquine treatment was*

TABLE 4.—*Tertian type of malaria and double infection in which treatment with plasmoquine was interrupted; further treatment with quinine.*

[, schizonts; ⁘, merozoits; ⁚, gametocytes; ↄ, crescents; T, tertian; E, æstivo-autumnal; , change in the medication; Q, quinine given.]

No.	Name.	Type of parasite.	Daily dose.	Days after treatment. 1	2	3	4	5	6	7
			g.							
1	L. F.	T ⁘ ⁚	0.12							
2	T. R.	T	0.12							
3	P. Qu.	T	0.12					Q		
4	M. D.	T	0.12			—	Q			
5	V. Z.	T	0.12			—	Q			
6	F. C.	T	0.12		E			E ↄ	3×2	E

No.	Name	Days after treatment. 8	9	10	11	12	13	14	15	16	17
1	L. F.		E				Q				
2	T. R.					—	Q				
3	P. Qu.										
4	M. D.										
5	V. Z.										
6	F. C.			E	Q						

TABLE 5.—*Three special cases of malaria.*

[○, schizonts; T, tertian; E, æstivo-autumnal; ⊕, gametocytes; !, abundant; _, change in the medication; ||, end of treatment.]

No.	Name.	Type.	Daily dose.	1	2	3	4	5	6	7	8	9	10	11	12	13
			g.													
1	A. E.	T	0.12							(a)				||		

No.	Name.	Type.	Daily dose.	3	7	10	13	15	17	20	22	25	28	30	32	35	37
2	T. A.	E	(b)	○							○	○ 3×2					||

No.	Name.	Type.	Daily dose.	3	6	8	10	13	14–38	39	41	43
			g.									
3	L. de C	T	0.12	○T	○T⊕	○T	○T	○E	(c)	○E 3×2	○E!!	○E!

[a] Without further medication. [b] Three times 1 tablet. [c] Under quinine treatment; æstivo-autumnal schizonts always present.

antecedent and the question of "accustoming" had been already raised.

Some cases merit special attention and are shown in Table 5.

Case 1 with simple tertian infection received 0.12 gram pure plasmoquine daily, over a period of six days. On the fourth day after treatment began the parasites had already disappeared from the peripheral blood. On the seventh day the patient refused to take any more medicine, either plasmoquine or quinine. Two days later tertian rings appeared again in the peripheral blood and remained there until the patient was discharged some days later.

Case 2 was a 12-year-old boy, with small æstivo-autumnal schizonts in the peripheral blood. One tablet three times a day only was given. Several times (see table) parasites were found up to the twenty-fifth day, when the medication was doubled. Three days later the parasites had disappeared and remained so until the thirty-seventh day, when the patient left the hospital. This evidently proves that even in children plasmoquine compound in half dose is in no way sufficient and the normal dose is well tolerated by them. This was also observed in case 4, Table 1, a girl of 7 years with simple benign tertian infection. The child received from the very beginning of treatment the full amount of 0.12 gram pure plasmoquine and tolerated it well, except for slight cyanosis of the finger tips.

Case, 3, a man of 24 years, showed in the beginning tertian schizonts in the peripheral blood. Under administration of pure plasmoquine, 0.12 gram daily, a few tertian gametocytes were found on the sixth day. On the thirteenth day small æstivo-autumnal rings were observed. From the following day to the thirtieth day (that is, over a period of twenty-four days) quinine sulphate, 1.8 grams daily, was given, but subtertian schizonts still persisted. Then plasmoquine compound, two tablets three times a day, was administered. After two days the subtertian schizonts were abundant in the peripheral blood. When the patient left the hospital two days later (that is, the forty-third day after treatment originally began), the parasites were found in decreased but still considerable numbers.

CONCLUSIONS

Concerning the action of pure plasmoquine in benign tertian infections we are able to confirm the good effect on all forms of the parasite as first reported by Muehlens. However, we

TABLE 6.—*Blood pictures in malaria.*

Specimen No.	Patient.	So-called youthful nonlobulated polymorphonuclears.	Nonlobulated polymorphonuclear forms.	Lobulated forms.	Lobulated "ring" forms.	Nonlobulated eosinophiles.	Lobulated eosinophiles.	Basophiles.	Monocytes.	Lymphocytes.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1	A., after 0.12 gram plasmoquine + quinine.		3	60	.....		3.5	.....	4	29.5
2	L. Cr., after 1.29 grams plasmoquine + 41.3 grams quinine.	.....	2	49	.....	8	....		6	35
3	F. Sehn		1	73	.....	.....	0.5	.....	9.5	16
4	do	2	2	60		.....	3.5		8	24.5
5	do	2	1.5	51.5	2	.....	2.5	.....	8.5	29
6	do	.....	2	58.5	0.5	.....	3	.....	5	31
7	do		1.5	64.5	.....		1.5		4.5	28
8	do		1	62.5			2		4.5	30
9	do	1	3	65.5			3		1.5	23
10	do	0.5	1.5	61	1		2.5		4	29.5
11	F. Sehn., relapse	0.5	1	68.5			[illegible]		5	22
12	F. Sehn	0.5	2.5	59			2.5		8	27.5
13	do		1.5	60.5			6		5	27
14	do	0.5	2	59.5	.....		3	....	5	30
15	do	.....	1	62.5		0.5	3.5		6	26.5
16	do	.....	2	53.5	.....	1	6	....	6.5	31

gave slightly larger doses (namely, 0.12 gram daily) in the beginning and found it valuable sometimes to increase the dose to 0.24 gram daily. Under such medication defervescence occurs early and, whereas in many cases parasites had disappeared on the second day after the beginning of treatment, in none of our cases could we find parasites for more than six days.

Splenic enlargement rapidly decreases under plasmoquine medication. Case 85, a private patient of Doctor Moreta whom he courteously sent us, previously had malaria. He had received quinine and showed no more parasites in the peripheral blood but had still a very large spleen. After plasmoquine the spleen rapidly decreased in size.

In a few cases tertian gametocytes, which could not be found in the beginning, appeared under plasmoquine medication, but disappeared again very soon.

In æstivo-autumnal infections it seems to us that with six tablets of plasmoquine compound daily (that is, 0.03 gram plas-

moquine and 0.375 gram quinine sulphate) the parasiticidal effect, though much superior to quinine, is yet not so striking as claimed by authors in Europe. However, it should be kept in mind that the general conditions in the Tropics, poorer food, and, doubtless, lower resistance of the poorer class are less favorable than conditions in European or American hospitals.

In a few of our cases the parasites persisted to the eleventh day, although we gave larger doses than originally suggested by Muehlens. However, this author has more recently recommended from 0.06 gram plasmoquine and 0.75 gram quinine to 0.08 gram plasmoquine and 1.0 gram quinine daily.

The effect of plasmoquine compound upon crescents is strongly pronounced, as Muehlens stated. However, as this author has already reported, we have observed likewise some cases in which crescents appeared for the first time under plasmoquine administration but soon disappeared with continued treatment.

In double infections we noticed frequently somewhat of a *provocative effect of plasmoquine.* This means in cases where primarily only tertian parasites were found, after administration of pure plasmoquine subtertian schizonts and even crescents appeared. In these cases treatment was continued with plasmoquine compound. On the other hand, under plasmoquine-compound administration the tertian parasites appeared in the peripheral blood, where only subtertian forms had been previously present. *But in these cases, only tertian schizonts appeared and never the sexual forms contradictory to the above-mentioned appearence of crescents in the suspected simple tertian infection.*

A few "plasmoquine-resistant" cases were observed by us, as shown in Tables 3 and 5.

Concerning the side effects we observed frequently more or less pronounced cyanosis which, however, was in none of the cases so alarming as to require the withholding of further plasmoquine medication. This cyanosis is often first observed on the nails and the finger tips, on the mucous membrane of the lips, and in the mouth. The face shows a very typical, pale, livid gray. The droplet of blood obtained by pricking the finger pad has a characteristic dark bluish-red color.

One of our cases even received up to 0.15 gram plasmoquine with 0.875 gram quinine daily, and showed no alarming side effects.

Though this cyanosis occurs more frequently and generally is more pronounced after medication with pure plasmoquine, we

have also noticed the same after administration of plasmoquine compound. We have not observed any relationship between this cyanosis and the severity of the malarial infection.

Muehlens, in his first publication,(5) considered circulatory disturbances responsible for the cyanosis. More recently, however, he has accepted the general consensus of opinion(9) that formation of methæmoglobin is the real cause. Not only methæmoglobin could be found after plasmoquine medication by Eichholtz(8) in man and by Le Haix and De Lind van Wyngaarden(24) in cats and rabbits, but the latter authors also showed that in vitro it may be formed by plasmoquine from the blood of men, cats, rabbits dogs, horses, cattle, sheep, and pigs.

Gastralgia was observed frequently in ward patients and especially if one patient had started to complain, the others followed. In none of our private cases did we hear any severe complaints. We therefore agree perfectly with Memmi and Schulemann,(8, 10, 11) Whitaker,(16) and others, that the degree of these abdominal pains is widely dependent on psychological factors, both of the patient and the observer. Though generally abdominal pains seem to occur more frequently after pure plasmoquine, they are also noted after plasmoquine compound medication.

The differential leucocyte count was made from a Giemsa-stained thin smear. This specimen was not made on a slide but on a cover glass after the procedure of Naegeli and as recently described by Hasselmann.(26) We have observed no remarkable effect of plasmoquine administration, except lymphocytosis as described by Memmi and Schulemann.(8) Table 6 shows sixteen examples of the leucocyte pictures. Concerning any direct visible action of plasmoquine upon the form or shape of the plasmodium, we have seen these curious parasites only upon or even just outside the border line of the erythrocyte, where the plasmodium itself seemed to be dying and stained very palely. We did not observe the so-called "Zerreissungsformen" as first described by Schaudinn(27) after quinine, nor could we feel thoroughly convinced of the "Degenerationsformen" as described after plasmoquine treatment by Memmi and Schulemann(10) and by Manson-Bahr.(18)

OUTLOOK

As already stated quinine is far from being the *therapia magna sterilisans* for malaria eradication. With the exception

of Billet(28) most authors, including Barber,(29) Bass,(30) Bignami,(2) Darling,(31) Gualdi,(32) James,(33, 34) Jancsó,(35) Macfie,(36, 37) Martirano,(32) Polettini,(38) Purjesz,(39) Rieux,(40) Schaudin,(41) Loewenstein,(42) Thomson,(43) Wenyon,(44) Werner,(45) and Yorke,(36, 37) consider that quinine does not affect the gametocytes and that patients receiving even 2 grams of quinine daily are infective for the biting mosquito. Furthermore, Yorke and Macfie(36, 37) showed that under experimental conditions only daily quinine treatment for ten days after the infectious bites could prevent the infection. Similar observations were made by Kirschbaum(46) in paralytics after injections of malarial blood.

As shown by James and Shute(47, 48) in their notable investigation with experimental infection of 2,630 female *Anopheles maculipennis*, it is most striking that a relatively small proportion of malarial-infected persons are infective to mosquitoes. They say:

> During this work it has been our experience that some patients with induced malaria are not at all infective to anopheles at any period of their malarial course, that others are only moderately so, and that rarely one comes across a patient who is strikingly infective.

The authors conclude that those patients are "good infectors" who carry a large number of gametocytes as found on blood examination, but in contrast to the opinion of Darling(31) and others who claim that one gametocyte to five hundred leucocytes (that is, twelve per cubic millimeter of blood) should be sufficient for infecting the mosquito, they had many failures even if the number of gametocytes was considerably in excess of this. The authors, therefore, have the impression that the quality of the sexual form, perhaps, the character of "ripeness," plays a more important rôle.

It is evident that apart from the mosquito conditions the incidence of gametocytes in man is the most important factor in the spread of malaria. From the epidemiologic standpoint cases of subtertian malaria treated with quinine may be for weeks a greater danger in labor camps than even the recently infected cases one finds in field surveys. Wenyon(44) and Clark(49) have shown that even after hospital treatment with up to 4 grams of quinine daily and without fever and symptoms, a large percentage of such cases remain gametocyte carriers. In view of this we may direct more attention to the fact that malaria is a "household disease" and as such might often

be dealt with in the houses rather than with antilarval methods. It should be remembered that Le Prince and Proctor(50) proved the efficiency in Panama of systematic mosquito catching in dwellings, as lately again recommended by James. However, conditions in the Philippines are somewhat different, since *Anopheles minimus*, the chief vector, has never been found resting in houses.

With this in mind the demonstrated gametocidal activity of plasmoquine permits us to return to Robert Koch's(51, 52) postulate that it is relatively more important to extirpate the malaria infection in the infected human carrier than to eradicate the mosquito as suggested by Ronald Ross.(53, 54) In order to avoid any misinterpretation we want to state positively that under favourable conditions in comparatively small areas mosquito-control work may remain the standard method. Examples such as Ismaïlia, the Panama Canal Zone, the Federated Malay States, some places in Dutch East India, the "bonifications" in Italy (incidentally, though not directly, antilarval), and lastly the very effective work in Jugoslavia as reported by Hasselmann (55, 56, 57) are widely enough known. The cost of this mosquito-control work justifies itself and can be maintained only in large commercial and industrial centers or populous residential districts. In rural districts and especially in large plantations we still consider the sufficient treatment of the diseased men as the most effective procedure. One of the world's most extensive plantation undertakings, the United Fruit Company, in its last annual report,(16) suggests the same view. (Also compare the Proceeding of the Seventh Congress of the Far Eastern Association of Tropical Medicine, Calcutta, the different views of Colonel James and Sir Malcolm Watson.)

In this respect we have in the new plasmoquine a remedy to cut the vicious circle of malarial infection in the human carrier by destroying the gametocytes, which are alone the infective source for the biting mosquito.

A few words may be said about the special conditions in the Philippines. Our patients came mostly, as already mentioned, from the Novaliches district, Rizal Province, about 25 kilometers north of Manila. This has been long known as a heavily infected malarial district. Judging from morbid incidence *Anopheles minimus* is supposed to be chiefly responsible for transmission, though *Anopheles barbirostris, philippinensis, hycranus, fuliginosus*, and *rossi* are found there too. Whereas *A. fuligi-*

nosus, *hycranus*, and *philippinensis* breed mostly in still water only, *A. barbirostris* and *rossi* are encountered in both still and running water. *Anopheles minimus*, the vector, is here found only in clear running water under shade. *Anopheles barbirostris* is usually found associated with *A. minimus*, but in more slowly moving rivers.

The Rockefeller Foundation and the Philippine Health Service have done some good work in San José, Mindoro; on the Calamba sugar estate, Laguna; and in the districts of Novaliches and Angat, where the new water supply for Manila is under construction. Quininization and mosquito-control work (the later mostly by the use of Paris-green powder) against *Anopheles minimus*, the chief vector, gave results which cannot be separated from each other. A prolonged and sufficient treatment of the patient, with the goal of freeing him from malaria gametocytes and especially from crescents, will no doubt prove still more effective than prophylatic medication with plasmoquine. We perfectly agree with the United Fruit Company, which urges *that no malaria patient should be discharged from the hospital who still has gametocytes in the peripheral blood* and that the discharged patients should remain under observation for a certain time. These means of freeing carriers from gametocytes are much more effective and economic. Such a desideratum, practically impossible with quinine, is now brought within practical lines through the addition of plasmoquine to our antimalarial armamentarium.

It may be stated that we consider 0.12 gram pure plasmoquine a day, given in dosis refracta, as a sufficient quantity for benign tertian infections. We have never seen any alarming side effect with this dosage that would have required the discontinuance of plasmoquine medication.

It is, however, more convenient to administer plasmoquine compound at once in cases where the least suspicion of a possible subtertian infection or a double infection exists. We refer to Muehlens,(9) who says:

> In all tropical countries where double infections with subtertian fever occur, plasmoquine compound should be given to avoid relapses of subtertian fever after tertian or quartan, respectively, have stopped.

Whereas this author thought temporarily to recommend smaller doses, he has increased them more recently(9) to 0.06 gram plasmoquine togather with 0.75 gram quinine a day; that is, six of the larger or twelve of the smaller tablets of plasmo-

quine compound. In our cases and in consideration of the small size of the average Filipino we found daily doses of 0.03 gram plasmoquine and 0.375 gram quinine sulphate sufficient in most of the cases, though much larger doses were well tolerated, as the tables show. In this respect special attention may be directed to case 25, Table 1, with tertian infection, who was given daily 0.32 gram plasmoquine for three days and 0.12 gram plasmoquine for eight days, altogether 1.92 grams plasmoquine without interruption in the course of eleven days without any considerable side effect. Case 26, Table 2, with æstivo-autumnal fever received up to 0.15 gram plasmoquine together with 1.875 gram quinine sulphate a day and tolerated it well. Even in this case, with the comparatively heroic dosage, two more rises of temperature occurred as shown in the text figure.

This fever curve, besides, is typical and might be given as an example. Furthermore, in this case, which was a European of 19 years and became infected on a kapok plantation in Novaliches district, it is noteworthy that crescents appeared on the thirty-eighth day after plasmoquine-compound treatment began, though the patient took the drug for four weeks but only very irregularly and in too small doses; namely, two small tablets a day for after treatment. *We cannot speak of a certain plasmoquine-fast strain of the parasite, because under continued and proper medication of the same drug, the parasites disappeared and did not reappear.*

Our observations are not sufficient to formulate proper conclusions concerning relapses, for most of the ward patients had to be discharged from further hospital observation to their respective camps. It may, however, be stated, that even of these laborers only one (case 23, Table 1) came back within five months with malaria, whereas laborers from the same camps, who had been treated with pure quinine, frequently came back for hospital treatment. Very often the latter then obtained plasmoquine treatment and were finally cured.

Case 26, Table 2, as already mentioned, had a relapse and even developed crescents. Muehlens(9) and Memmi and Schulemann(10) admit that this may happen but very seldom.

We did not observe, as reported by Vad and Mohile(58)[4] and by Baerman and Smits,(14) that the natives tolerate plasmoquine better than white people.

[4] These authors recently reported very satisfying results of plasmoquine treatment in sixteen cases of malaria.

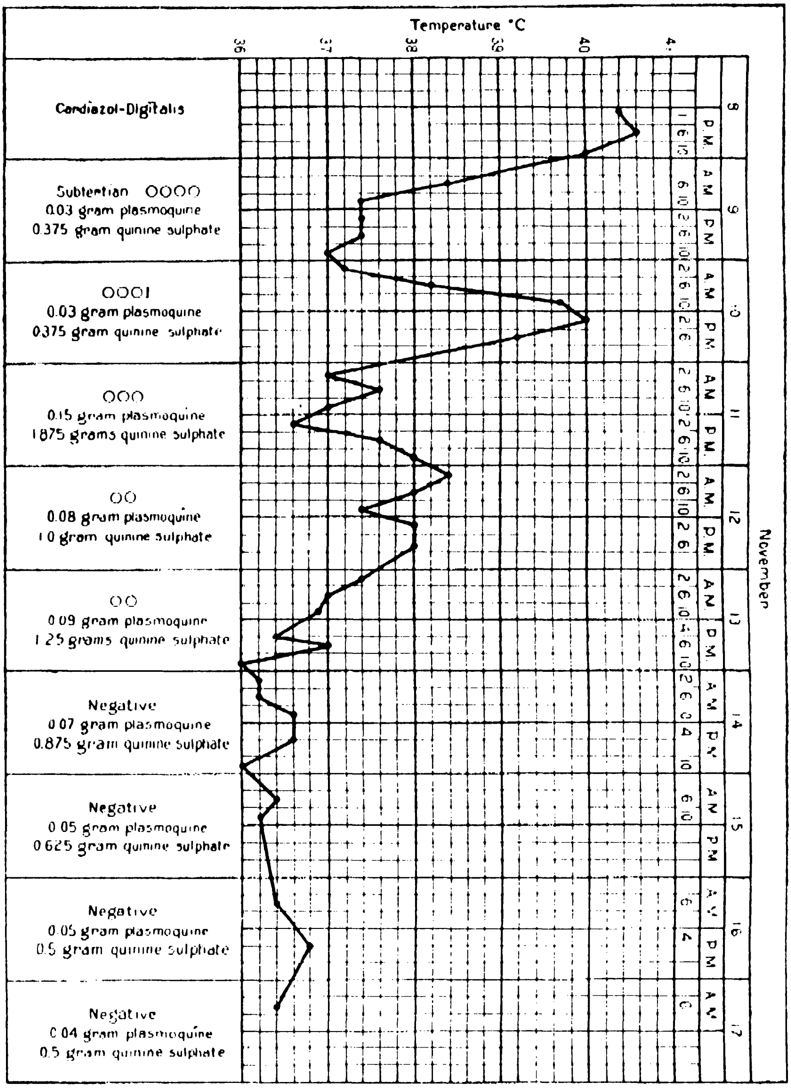


FIG. 1. Temperature chart of a malarial patient treated with plasmoquine and quinine.

Concerning the differential leucocyte count Memmi and Schulemann(8) report a lymphocytosis up to 50 per cent after plasmoquine treatment. In some of our cases we could verify this. Table 6 shows sixteen blood pictures.

Finally, the question arises as to the value of plasmoquine in the Philippines. There are about 25,000 deaths reported each year due to malaria. Good work has been done since 1922 under the direction of the International Health Board, the Philippine Health Service, and the United States Army and Navy authorities. Field work, started in Olongapo, Zambales; Del Carmen, Pampanga; and various districts in Laguna Province and carried over certain parts of the country proved successful. Even in San José, Mindoro, once known as the "white man's grave," quinine prophylaxis together with spraying of Paris-green powder have done much to better conditions, but we must not expect too much of these measures. For instance, during the second week of February, 1926, in one of the Novaliches camps there was a morbidity of more than 20 per cent of all laborers who had to be transferred for hospital treatment, and this was in the very neighborhood of Manila! Conditions, however, have improved; the vector in the Novaliches district is apparently *Anopheles minimus* alone, and all streams and running waters are now continuously sprayed. In December, 1927, an epidemic outbreak of malaria among the Igorots near Ibulao River, Mountain Province, Luzon, was reported,(59) not to speak of the vast areas in Mindanao where only malaria prevents exploitation of one of the gobe's most fertile soils.

We wish to direct attention to the more economical possibility of breaking the vicious circle of malaria in man by administering plasmoquine, not prophylactically, but as sufficient treatment of the infected, thus freeing him from gametocytes and making him sterile for the biting mosquito, the ineradicable animal of tropical countries.

SUMMARY

1. Ninety cases of naturally acquired malarial infection were treated with plasmoquine.[5]

[5] We had no opportunity to treat cases of pneumonia with plasmoquine as did H. Schlesinger, who reports early defervescence after its administration. Muench. med. Wo. No. 11 (1927) 479.

2. Forty of these cases were tertian infections and received from 0.12 to 0.32 gram of pure plasmoquine daily in dosis refracta. They were freed from parasites in from two to six days after treatment began.

3. Thirty-one of the cases were simple æstivo-autumnal infections and received "plasmoquine compound" on an average from one tablet three times (child) to five tablets four times a day. Each tablet contained 0.005 gram plasmoquine and 0.0625 gram quinine sulphate. They were freed from parasites in from two to ten days after treatment began.

4. Eighteen cases were double infections. Those that showed in the first blood examinations only tertian parasites were given pure plasmoquine, which was changed to plasmoquine compound as soon as the double nature of the infection was revealed. The other cases, with both types of parasites or with only subtertian forms in the beginning, were given plasmoquine compound at once.

5. In all cases—most pronounced in case 85—splenic enlargement rapidly decreased.

6. It seems that in double infections plasmoquine has somewhat of *a provocative effect;* that is, where only one type of parasite is found in the peripheral blood, after administration of pure plasmoquine the subtertian forms appear in the peripheral blood; and after administration of plasmoquine compound, on the other hand, the tertian forms often appear; but in these cases only tertian schizonts appeared and never the sexual forms contradictory to the above-mentioned appearance of crescents in the suspected simple, benign, tertian infection.

7. It is remarkable that small æstivo-autumnal rings persisted for a longer time in the peripheral blood if previous medication of pure plasmoquine had been given. Therefore the question of a certain "accustoming" arises.

8. Whereas our observations do not warrant final judgment concerning relapses, these were exceptionally few as compared with relapses after quinine medication.

9. Side effects, such as gastralgia and abdominal pains, cyanosis of the lips and the finger tips, and paleness of the skin, may occur, especially after pure plasmoquine, but never required the discontinuance of the medication. On the other hand these possible *side effects make medical supervision absolutely indispen-*

sable[a] and plasmoquine unfit for self treatment, after treatment, or prophylaxis without this medical care. Likewise, we do not consider plasmoquine suitable for prophylaxis, on a large scale, except under strict daily medical supervision for a possible sterilization of a certain population, say for about ten days, with the goal of freeing all possible carriers from gametocytes.

10. We recommend the following doses:

A. In tertian infections—
 0.10 gram plasmoquine daily, best given as one tablet of 0.02 gram, five times a day. This dose may be eventually doubled.

B. In æstivo-autumnal or in double infections—
 Five times a day one tablet plasmoquine compound, each of 0.01 gram plasmomoquine and 0.125 gram quinine sulphate; that is, 0.05 gram plasmoquine and 0.625 gram quinine sulphate a day; that is, at least 0.001 gram plasmoquine per kilogram weight.

Although we consider these doses sufficient in most cases, in one case with tertian infection we gave up to 0.32 gram plasmoquine daily and in the course of eleven days altogether 1.92 grams plasmoquine without interruption and without any considerable side effects. Another case (26, Table II), with subtertian fever, received up to 0.15 gram plasmoquine together with 1.875 grams quinine sulphate a day and in the course of seventy-six days a total of 1.62 grams plasmoquine and 22.25 grams quinine sulphate, also without any alarming side-effects.

11. Our experience confirms to a large extent, Muehlens's first report that this new antimalaric is superior to quinine in tertian infection and its action as specifically "gametocidal" in subtertian fever.

12. We may compare plasmoquine with the "Altsalvarsan," which was very soon improved after its discovery by Ehrlich himself. Therefore, we agree with the following statement of Manson-Bahr:(17)

> Plasmoquine has to be regarded as the first of a new series of antimalarial synthetic drugs, and not as the climax of what has already been accomplished. The future is distinctly hopeful as regards the synthesis of a still more efficient antimalaric compound.

[a] We, therefore, cannot follow the views of Benecke, but are in line with the oficials of the United Fruit Company (Sixteenth Annual Report).

The administration of plasmoquine [7] in combination with quinine as plasmoquine compound has been demonstrated to be markedly successful in freeing the victim of malaria from gametocytes. This brings nearer accomplishment *the original suggestion of Robert Koch to break the vicious circle of malaria by destroying the sexual forms of the malarial parasite in the human carrier.*

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[7] Plasmoquine is manufactured and sold in tablets, each containing 0.02 gram. Plasmoquine compound is manufactured and sold in tablets. The dragées and the larger tablets contain 0.01 gram plasmoquine and 0.125 gram quinine sulphate, the smaller tablets one-half these amounts; namely, 0.005 gram plasmoquine and 0.0625 gram quinine sulphate. However, they are no longer manufactured. More recently ampoules for hypodermic and intravenous use have been put on the market.

The question is frequently asked, at the current prices of the two drugs which is more expensive, treatment with quinine or with plasmoquine compound and pure plasmoquine.

The base treatment of 30 grains of quinine sulphate per day, say for five days and then 10 grains per day for eight weeks would require one hundred forty-two 5-grain tablets; the schema of Nocht, Manson-Bahr, Ziemann, and others, would demand somewhat less, about ninety-five 5-grain tablets; that is, about 31 grams. At current prices 5-grain tablets cost 1.4 centavos each. Therefore, the base treatment would cost about 2 pesos (equivalent to 1 dollar in United States money); that of Nocht, and others, would cost about 1.30 pesos.

On the other hand treatment and after-treatment with plasmoquine compound would require according to Muehlens—and this is rather the upper limit in our experience -132 of the larger tablets. The local price for this amount would be a little over 5 pesos, if based on the price of 1,000 pesos for 25,000 of the larger tablets as the cheapest sold unit.

The administration of quinine and plasmoquine in separate tablets would be somewhat more complicated, but at the same time considerably cheaper—about 2.98 pesos, if based on the price of 1,650 pesos for fifty thousand 0.02-gram tablets of pure plasmoquine. It would be necessary to give only three of these tablets daily, which would be equal to the amount of plasmoquine in six tablets of "plasmoquine compound" and 0.75 gram of quinine in the form of two and one-half 5-grain quinine sulphate tablets.

Therefore, the cost of plasmoquine compound treatment is about as 5 to 2 or 1.3 as compared with quinine treatment. However, the difference in efficiency; that is, difference between probably not destroying the gametocytes on the one hand and of almost certainly destroying them on the other, cannot be estimated in money.

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ILLUSTRATION

TEXT FIGURE

FIG. 1. Temperature chart of a malarial patient treated with plasmoquine and quinine.

NOTES ON MALARIA TRANSMISSION

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FOUR PLATES

Banks,[1] in 1907, claimed to have produced artificial malarial infection in *Anopheles ludlowii* (salt-water type) and reproduced the disease in a volunteer. His evidence, however, is inconclusive. He showed microphotographs of sections of supposedly infected salivary glands, the only microphotographic illustrations of sporozoites I know of in available Philippine literature on malaria.

Walker and Barber,[2] in 1914, experimented with *Anopheles minimus* Theobald (*A. febrifer* Banks), *A. rossii* Giles, *A. barbirostris* van de Wulp, *A. hyrcanus* Pallas, and *A. maculatus* Theobald, and succeeded in producing the highest infection rates in the stomachs and the salivary glands of *A. minimus*. They concluded that *A. minimus* is probably the most important transmitter of malaria in the Philippines.

In a subsequent paper Barber [3] included *A. maculatus* with *A. minimus* as one of the chief transmitters of malaria although to a lesser extent.

By circumstantial evidence the Rockefeller investigators [4] incriminated *A. minimus* and *A. ludlowii* (fresh-water type), stream and river breeders, respectively, as the main vectors.

The present notes are preliminary in nature and give briefly the recent findings of the malaria section of the Philippine Health Service on malaria transmission during its first year of existence.

Little material will be presented, as the major part of the year was spent in routine surveys, organization, and establishment of control areas.

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The merits of the study of malaria transmission by experimental or by natural infection will not be gone into for the present, nor will the question of why one species may be a very important vector in one country and not in another be touched. The method followed in the dissection of wild-caught mosquitoes and the result so far attained will be given. Microphotographs are presented, particularly those of the sporozoites, to compare with those of Banks in *Anopheles ludlowii*. Different stages of the oöcyst in the stomach are also illustrated. A section of the thoracic ganglion of *Culex* (Plate 5, fig. 2) is also given for comparison with Bank's microphotographs of sporozoites. Comparison of this figure with Banks's Plate 9, fig. 4, would seem to show that Banks mistook the nuclei of the neurones for sporozoites.

ANOPHELES SURVEYS

In a survey of sixty-nine malarious places in Luzon and Mindoro, *Anopheles minimus*, a stream breeder, was found in sixty-four (93 per cent) of the places, and the predominant species in fifty-three (77 per cent). It is believed that if larval collections were made during the malaria seasons in all these places, *A. minimus* would probably be found in almost all and the predominant species. There may be a few localities where *A. minimus* is not the natural vector, but this remains to be shown by further observations. In a survey of twenty-five places in Mindanao and Sulu, of which eleven were malarious, where malaria was present *A. minimus* was always found, alone or with the other species; while when *A. minimus* or its potential breeding place was absent, the other species present or abundant, there was invariably no malaria. Of course, the presence of *A. minimus* does not necessarily imply the presence of malaria. It was on the basis of the Mindanao findings that "species control" against *A. minimus* was recommended by the writer and approved by the Advisory Committee on Malaria Control in April, 1927. This limits Paris-green control to streams and irrigation ditches found to be *A. minimus* breeders.

In localities with permanent streams it has often been said and also observed that the peak of the malaria season coincides with the dry season (rice harvesting) and with the abundance of *A. minimus* breeding when the water is clear and at a constant level. During the rainy season the flooding carries the larvæ away, hence lower malaria incidence. There are places, however, where the malaria season starts after the rain and

decreases during the dry season. This condition has been found to be due to the formation of rain or temporary streams, the *A. minimus* breeding places, which as a rule dry out during the dry season. Both of the above conditions apparently exist in the Novaliches water project, in Rizal Province, Luzon, with more cases during both the dry and the rainy season. Of course, the nature of the work (excavation and filling) and consequent lowered resistance and exposure during rains, might have caused more cases and relapses.

HABITS OF ADULT ANOPHELES MINIMUS

No systematic study has been made of the habits of *Anopheles minimus*. What will be given here are only incidental observations from September to December, 1927, inclusive, in La Mesa (Novaliches water project), while looking for the insects for dissection purposes. La Mesa is the second worst malaria district encountered in about two hundred surveys, with 84 per cent splenomegaly and 53 per cent positive blood in children and at least 46 per cent blood positive among active laborers who receive 10 grains of quinine daily.

The adult mosquito is typically "wild" in that it is very seldom found in the ordinary nipa house at night, much less in the day time. The only occasions on which they have been caught during the day time were when they were imprisoned inside wire screens. During the period of heavy catches they have shown preferential harborage in two houses out of about seventy-five, and incidentally where most of the new malaria cases were registered. Why this is so has not been studied, but it may be that these houses are suitably located in the mosquitoes' line of flight; due to favorable winds; near the nearest breeding places beyond the control areas; or, that the houses are firmly built and not subject to much vibration.

Most of the catches were made outside the houses and by exposure of the body and the limbs of the catchers. Flashlight is indispensable to spot them. The best time to see them in Novaliches is in the latter part of the evening. Mosquito traps have not yet been studied.

Of over twenty-seven hundred adult *Anopheles* caught, only two were males. This may be due to the fact that as most of the catches were by exposure the nonbiting males were not attracted; or, the area being under control, the breeding place from which the females come is beyond the 1.5-kilometer limit; or for some unknown reason.

DISSECTION

The basis for identification of species will not be gone into, suffice it to say that Strickland's Manual was used and found to be a very simple guide.

Method.—For a successful dissection the primary requisite is a mosquito freshly killed with a drop of chloroform or tobacco smoke applied to the mouth of the test tube containing the insect. Insects long dead are unsatisfactory, as they are hard and brittle. After the species has been determined, a fine sewing needle in a handle (needle 1) is thrust into the thorax, either dorsal, lateral, or ventral side, preferably toward the caudal half in order to avoid the salivary glands. The legs and the wings are removed with a pair of entomological forceps or the fingers. Place a drop of normal salt solution on the middle of a slide, and with the aid of another dissecting needle (needle 2) carefully detach the mosquito from needle 1 and lay it on its side on the slide, the head on the edge of the salt drop. Place needle 1, held with one hand, on the thorax lightly but firm enough to hold it down so that the needle is almost parallel to the surface of the slide. Needle 2, held with the other hand, also parallel to the surface of the slide and to needle 1, is now placed on the head or the proboscis and with sufficient pressure to hold but not crush the head. Carefully pull the head intermittently from the thorax. The secret of pulling out the lobes of the salivary glands lies in the slowness of traction on the head. The longer one can keep the head and the thorax within 1 to 2 millimeters distant from each other during the traction, the greater are the chances of success. During this stage both hands should rest on the table. When properly done, one will see white specks, the salivary glands, the œsophagus, and sometimes air bubbles between the head and the thorax floating in salt solution. To be sure of success, one should examine from time to time the region of the neck during this step. Once the glands are pulled out of the thorax, they are cut from the head at its junction with the needle. If one fails to get the glands with the head, he should proceed to pull out the stomach, and then return to the thorax and tease out the salivary glands by tearing carefully with the two needles the region of the thorax nearest the first coxæ with repeated examination under a low power. The salivary glands are easily recognized as two highly refractile sausage-shaped structures, each of which has

three lobes. A total of seven lobes in one insect has been observed twice.

The stomach is isolated in the same way as the salivary glands. Needle 1 is applied to the thorax with the abdomen in salt solution. Needle 2 is applied at about the caudal fourth or third of the abdomen and careful intermittent traction applied with needle 2. The abdominal casing will break at the point of application of needle 2 and expose the intestine, Malphigian tubules, and ova, if any. Should the abdominal casing fail to break at the point where needle 2 is applied, a puncture on its edge will start the break. Further traction will reveal the whole midgut and often a large portion of the entire foregut. Sometimes the abdomen breaks off at its junction with the thorax before the stomach is exposed. In that case needle 1 is applied at the cephalic third or fourth of the abdomen. Much pressure in the caudal third or fourth may sever that part of the abdomen without exposing the midgut. In that case the abdominal casing is torn on the edge and carefully pulled off the stomach. In a distended abdomen filled with blood or ova careful pressure, rolling the needle, from the cephalic to the caudal portion will press out the stomach and all. Repeated examination under the microscope during the process of dissection is very important.

It is preferable that the salivary glands be removed first, as the severed œsophagus will facilitate subsequent traction on and isolation of the stomach.

Oöcyst.—The nodular corrugations characteristic of a freshly isolated stomach from a recently killed mosquito should not be confused with oöcysts. Cysts have different refraction from the stomach tissue proper, and are uneven in distribution. They are best seen under a cover glass which is lightly pushed while the stomach is under view. The cyst on reaching a profile position will appear to be a distinct and complete spherical body with a wall and attached to the outer surface of the gut, while contractile corrugations are half spheres and regular in distribution. Small cysts may contain only spherical hyaline bodies, while the larger ones are filled with granules, bacillary structures, or spindles. A positive stomach may be preserved and mounted in 3 to 5 per cent formalin and the cover slip ringed with vaseline.

Sporozoites.—An infected salivary gland very frequently ruptures during the process of isolation. The sporozoites are

easily identified even with a $\frac{1}{6}$ objective as numerous highly refractile bent rods, "vibrio-like," pouring from the ruptured side of a lobe. Before discarding the salivary gland as negative, apply a cover glass, press lightly, and push the cover glass to one side. If sporozoites are present, they will be discharged from the crushed gland. For the study of the morphology of the sporozoites, the cover glass is lifted and both the slide and the cover glass are allowed to dry. Treated with absolute methyl alcohol for a few minutes, washed in distilled water and stained with Giemsa, preferably a weaker solution than the one used for blood smears if one attempts to demonstrate the sporozoites within the gland. Even then, gland cells usually take a deeper stain and obliterate the contained sporozoites. Isolated sporozoites, however, could easily be identified as slender, usually bent, spindles at least 10 microns in length, often much longer, with tapering ends, blue cytoplasm, and a red nucleus.

The specimens successfully dissected from September 1 to December 31, 1927, and the positives found are distributed as to species as shown in Table 1.

TABLE 1.—*Number of mosquitoes dissected, by species.*

Species.	Number.	Stomach positive.	Per cent positive.	Salivary gland positive.	Per cent positive.
Anopheles minimus	2,283	19	0.83	8	0.35
Anopheles hyrcanus	77	0	.0	0	.0
Anopheles barbirostris	60	0	0	0	.0
Anopheles rossii	41	0	.0	0	.0
Anopheles karwari	27	0	.0	0	.0
Anopheles tesselatus	5	0	.0	0	0
Anopheles fuliginosus	194	0	.0	0	.0
Anopheles philippinensis	5	0	.0	0	.0
Anopheles maculatus	1	0	.0	0	.0

From these observations it is evident that *Anopheles minimus* is a natural vector of malaria in the Philippines. This species can be controlled by dusting streams with a mixture of Paris green and road dust, so that engineering projects have not been shown to be necessary in the control of malaria in the Philippines.

SUMMARY

1. Circumstantial evidence in about eighty malarious places and direct evidence in the second worst of these places, point to *Anopheles minimus* as the natural vector of malaria so far

found in the Philippines. It is possible that other species may, in certain localities, also transmit malaria under natural conditions, but this has to be shown by further observations.

2. The percentage of positives for natural infection of *A. minimus* are 0.83 per cent for the stomach and 0.35 per cent for the salivary gland.

3. The findings justify "species control" which limits larval control to streams and irrigation ditches breeding *A. minimus*. Engineering projects are not, as far as the present surveys indicate, necessary in the control of malaria in the Philippines.

4. The "wild" nature of *A. minimus* precludes campaign against the adults. Traps have not yet been tried.

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ILLUSTRATIONS

[Microphotographs by the Bureau of Science.]

PLATE 1

FIG. 1. *Anopheles minimus* Theobald; normal stomach, showing contractile corrugations of the stomach wall and a small amount of blood. Fixed and mounted in 3 per cent formalin. × 100.

2. *Anopheles minimus* Theobald; stomach with oöcyst. Fixed and mounted as in fig. 1, but slightly flattened by the weight of the cover glass. × 100.

3. *Anopheles minimus* Theobald; stomach filled with blood and many young oöcysts. Fixed in Bouin's fluid and stained with iron ammonium sulphate and hæmatoxylin. × 100.

PLATE 2

FIG. 4. *Anopheles minimus* Theobald; stomach with four young oöcyst; fresh, mounted in salt solution, flattened and distorted by the cover glass. × 450.

5. *Anopheles minimus* Theobald; stomach, showing one more-mature oöcyst in the center with granular material and distinct cyst wall. Fixed in Zenker's fluid and stained with iron ammonium sulphate and hæmatoxylin. × 1000.

PLATE 3

FIG. 6. *Anophels minimus* Theobald; the same specimen as that of fig. 5, showing the matured cysts and sporozoites.

7. *Anopheles minimus* Theobald; salivary gland, showing sporozoites. Fixed in formalin and stained with hæmatoxylin-eosin. × 600.

8. *Anopheles minimus* Theobald; a lobe of the salivary gland, showing most of the cells filled with sporozoites. Fixed in absolute alcohol and stained with iron ammonium sulphate and hæmatoxylin. × 1000.

PLATE 4

FIG. 9. *Anopheles minimus* Theobald; isolated sporozoites from a ruptured lobe of the salivary glands. Fixed in Zenker's fluid and stained with Delafield hæmatoxylin. × 1000.

10. Domestic *Culex*, section of the thoracic ganglion. Fixed in alcohol and stained with hæmatoxylin-eosin, showing the nuclei of the neurones which Banks mistook for sporozoites.

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PLATE 1.

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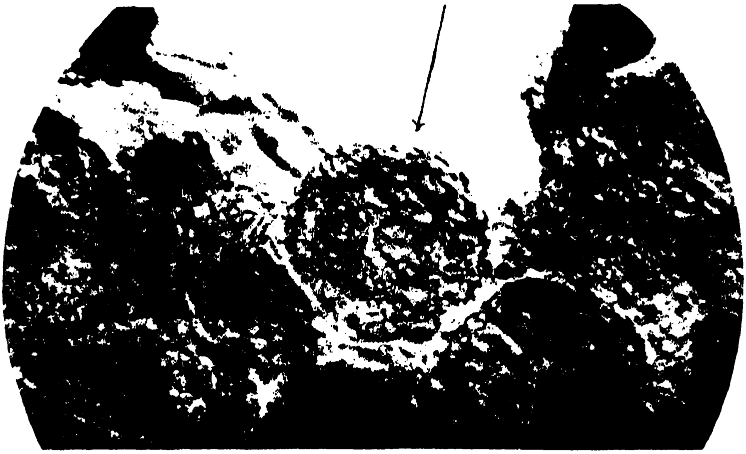

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PLATE 4

THE PHILIPPINE
JOURNAL OF SCIENCE

VOL. 37 OCTOBER, 1928 NO. 2

NEW PHILIPPINE PLANTS

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FOUR PLATES

In the following contribution one new genus and seventy-two new species, representing thirty-two families, from recent collections made in various parts of the Philippines, are described. The genus *Alseodaphne*, of the Lauraceæ, is credited to the Philippines for the first time as well as the following three species, the first of which was originally described from Borneo: *Ixora tenelliflora* Merrill, *Boehmeria malabarica* (Wallich) Weddell, and *Torenia cordifolia* Roxburgh. A few notes on nomenclature are included, especially in the Tiliaceæ.

Unless otherwise indicated in the text, the actual types of the new species described are deposited in the Bureau of Science herbarium, Manila, with isotypes in the herbarium of the University of California. In a few cases the types are in the University of California herbarium, with isotypes in the Bureau of Science. As far as additional duplicates are available, material

[1] This investigation was carried out at the University of California under a National Research Council Fellowship in the Biological Sciences 1926–1928, and while on leave as Assistant Professor of Plant Physiology, College of Agriculture, University of the Philippines.

will be sent to several of the larger European and American herbaria. The drawings were made by the senior author.

PANDANACEÆ

Genus PANDANUS Linnæus

PANDANUS NOBILIS sp. nov. § Keura. Plate 1.

Frutex 2 ad 4 m altus, ramosus; foliis 2 ad 3 m longis, 8.5 ad 12 cm latis, rigidis, longe attenuatis, supra nitidis, subtus glaucis, margine spinulosis, costa subtus denticulata, nervis lateralibus supra in partibus superioribus denticulatis; syncarpiis solitariis, ellipsoideis, pendulis, circiter 27 cm longis, 16 cm diametro; drupis numerosis, 8- ad 12-locellatis, oblongis vel oblongo-obovoideis, 5 ad 6.5 cm longis, 3.2 ad 5 cm diametro, hexagonis, truncatis, loculis irregulariter dispositis, subpyramidatis, sulcis interlocularibus haud profundis; stigmatibus erectis, suborbicularibus ad reniformibus, 1 ad 2.5 mm diametro.

A shrub or small tree, 2 to 4 m high, the stem about 10 cm in diameter with 5 or 6 branches. Leaves 2 to 3 m long, 8.5 to 12 cm wide, rigid, long attenuate, shining above, glaucous beneath, the marginal spines very numerous, the midrib spiny on the lower surface, the spines becoming more numerous toward the apex, the lateral nerves at the apex on the upper surface denticulate. Syncarps ellipsoid, about 27 cm long, 16 cm in diameter, solitary, pendulous, their peduncles up to 60 cm long, stout, up to 4 cm in diameter below. Drupes numerous, oblong or oblong-obovoid, red when fresh, 5 to 6.5 cm long, 3.2 to 5 cm in diameter, the free portions 6-angled, the apex truncate, locules irregularly disposed, their tips somewhat pyramidal, the furrows between the locules shallow; stigmas erect, suborbicular to reniform, 1 to 2.5 mm in diameter.

LUZON, Tayabas Province, Casiguran, *Bur. Sci. 45568 Ramos and Edaño* (type), May 5, 1925, along streams in damp forests at low altitudes: Isabela Province, San Mariano, *Bur. Sci. 46752 Ramos and Edaño*, March, 1926, along forested streams, altitude about 400 meters.

A species belonging in the group with *Pandanus exaltatus* Blanco, differing in its larger drupes and much larger syncarps.

PANDANUS UMBONATUS sp. nov. § Vinsonia.

Frutex erectus, parce ramosus; foliis 1.65 ad 2.2 m longis, 3 ad 5.6 cm latis, rigidis, crasse coriaceis, pallidis, sursum angustatis, acutis, vix acuminatis, margine spinulosis, subtus glaucis;

syncarpiis 2 ad 4, ellipsoideis ad subglobosis, racemose dispositis, 7.5 ad 11.7 cm longis, 6.5 ad 8.5 cm diametro, sessilibus vel breviter pedunculatis; drupis 20 ad 30, obovoideis vel oblongo-obovoideis, 3.1 ad 4.3 cm longis, 2 ad 2.8 cm diametro, 5- vel 6-gonis, 5- ad 8-locellatis, apice perspicue umbonatis, umbo 6 ad 10 mm diametro.

An erect shrub, the stem 3 to 4 cm in diameter, with few, usually 2 or 3, branches. Leaves 1.65 to 2.2 m long, 3 to 5.6 cm wide, rigid, thickly coriaceous, pale when dry, glaucous beneath, narrowed upward, acute, scarcely acuminate, marginal spines somewhat distant, ascending, the midrib spines on the lower surface prominent, recurved. Infructescence terminal, pedunculate, the peduncle 23 to 29 cm long, 3-angled. Syncarps 2 to 4, ellipsoid to subglobose, 7.5 to 11.7 cm long, 6.5 to 8.5 cm in diameter, sessile or peduncled, the peduncles up to 2.5 cm long. Drupes 20 to 30 in each syncarp, 5- to 8-celled, obovoid or oblong-obovoid, 3.1 to 4.3 cm long, 2 to 2.8 cm in diameter, the upper one-half free, narrowed below, apex prominently umbonate, the umbo 6 to 10 mm in diameter, 5- or 6-angled, the locules irregularly disposed, the apical furrows shallow and usually not conspicuous; stigmas sessile, plane, orbicular to somewhat reniform, 0.75 to 1.5 mm in diameter.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 46967* (type), *46998 Ramos and Edaño*, February 22, 1926, in damp forests, at 600 meters altitude; Mount Moises, *Bur. Sci. 47347 Ramos and Edaño*, abundant along streams in damp forests, altitude about 800 meters.

This species is characterized by its rigid glaucous leaves, its racemose syncarps, and its umbonate drupes.

GRAMINEÆ

Genus PANICUM Linnæus

PANICUM ANCYLOTRICHUM sp. nov. Plate 2.

Subscandens, parce ramosis, saltem 1 m altis, culmis 2.5 ad 3 mm diametro, spiculis ligulisque exceptis glaber; vaginis quam internodis brevioribus; laminis lineari-lanceolatis, attenuatis, 7 ad 13.5 cm longis, 2.5 ad 7 mm latis, glabris, margine scaberulis; paniculis angustis, pauci ramosis, 7.5 ad 17.5 cm longis, ramis adcendentibus, remotis, inferioribus, usque ad 4 cm longis; spiculis anguste oblongo-ellipsoideis, acutis, circiter 3.5 mm longis, pedicellis usque ad 4 mm longis, glumis II et III pilis numerosis uncinatis instructis, I puberulis.

Culms subscandent, slender, wirelike, at least 1 m high, 2.5 to 3 mm in diameter below, few-branched, glabrous, smooth, the nodes glabrous; sheaths glabrous, shorter than the internodes; ligule small, densely ciliate; leaf blades linear-lanceolate, attenuate, 7 to 13.5 cm long, 2.5 to 7 mm wide, glabrous, the margins scaberulent. Panicles narrow, 7.5 to 17.5 cm long, the branches few, ascending, glabrous, remote, slender, the lower ones up to 4 cm long. Spikelets few, sessile and pedicelled, the pedicels up to 4 mm long, oblong-ellipsoid, acute, about 3.5 mm long; the first glume shorter than the spikelet, ovate-lanceolate, acute, puberulent, 3-nerved, about 2 mm long; the second and the third glume subequal, covered with numerous slender hooked hairs, narrow oblong-elliptic, acute, the third one 5-nerved, 3 to 3.25 mm long, the second 7-nerved, about 3.5 mm long; flowering glume glabrous, shining, narrowly oblong-ellipsoid, about 3 mm long, narrowed to the acute apex, minutely apiculate.

MINDANAO, Davao Province, Mati, *Bur. Sci. 49069 Ramos and Edaño*, April 9, 1927, along Dawan River, in thickets and forests and in the open, at low altitudes.

A unique species totally different from all hitherto known Philippine forms, specially characterized by its second and third glumes being densely covered with slender hooked hairs, as well as by its habit. A specimen was sent to Prof. A. S. Hitchcock who reports that it represents a species not matched in the United States National Herbarium and that it appears to fall in the genus *Panicum* in the restricted sense. It differs from the other species of *Panicum* sensu strictiore in the characteristic uncinate hairs of the second and the third glume, yet from this character alone it hardly seems warranted to segregate it as a distinct generic type.

ARACEÆ

Genus SCHISMATOGLOTTIS Zollinger and Moritzi

SCHISMATOGLOTTIS CARDIOPHYLLA sp. nov.

Caudiculi hypogaei, 1.3 ad 1.6 cm diametro; foliis late cordato-ovatis, 33 ad 38 cm longis, 22 ad 24 cm latis, breviter acute acuminatis, basi profunde cordatis, lobis late rotundatis, 5.5 ad 9 cm longis, 9 ad 11.5 cm latis, supra olivaceo-viridibus, subtus pallidis, glaucescens, utrinque glabris; nervis lateralibus utrinque numerosis, perspicuis; petiolo 24 ad 39 cm longo, vaginis 16 ad 23 cm longis; inflorescentiis 7 ad 9; bracteis numerosis, 11 ad 14 cm longis, linearilanceolatis, attenuatis, acutis; pedun-

culis valde elongatis, 12 ad 15 cm longis; spathis oblongo-lanceolatis, longe acuminatis, albidis, 6 ad 7.5 cm longis; spadicis stipitatis, partibus ♀ circiter 1.5 cm longis, ♂ circiter 2.1 cm longis, partibus sterilibus cylindraceis, conicis, obtusis, usque ad 1.5 cm longis; baccis 2 ad 2.25 mm longis, 1.25 ad 1.75 mm latis, oblongis, striatis, flavidis.

Stem 1.3 to 1.6 cm in diameter. Leaves broadly cordate-ovate, 33 to 38 cm long, 22 to 24 cm wide, shortly and acutely acuminate, base deeply cordate, the lobes broadly rounded, 5.5 to 9 cm long, 9 to 11.5 cm wide, olivaceous-green above, paler and glaucous beneath, glabrous on both surfaces; lateral nerves numerous on each side of the midrib, prominent; petioles 24 to 39 cm long, the sheathing parts 16 to 23 cm in length. Inflorescences 7 to 9, the bracts numerous, 11 to 14 cm long, linear-lanceolate, acutely attenuate; peduncles 12 to 15 cm long. Spathes oblong-lanceolate, long acuminate, white, 6 to 7.5 cm long. Spadix stipitate, up to 4.5 cm long, the pistillate portion up to 1.5 cm long, the staminate part contiguous to the pistillate, up to 2.1 cm long, the sterile portion cylindric, conic, blunt, up to 1.5 cm long. Fruits 2 to 2.25 mm long, 1.25 to 1.75 mm in diameter, oblong, conspicuously striate, yellowish.

LUZON, Tayabas Province, Casiguran, *Bur. Sci. 45387 Ramos and Edaño*, June 11, 1925, along streams in damp forests, at low altitudes.

A species in the group with *Schismatoglottis calyptrata* (Roxburgh) Zollinger and Moritzi and apparently near *S. luzonensis* Engler. It differs from the latter by its smaller leaves longer spathes, longer and larger spadix, shorter stamens, and oblong staminodes. The very long sheaths are conspicuous in this species.

TACCACEÆ

Genus TACCA Forster

TACCA ELMERI Krause.

Tacca elmeri KRAUSE in Elm. Leafl. Bot. 6 (1914) 2283; MERRILL, Enum. Philip. Fl. Pl. 1 (1925) 214; LIMPRECHT in Pflanzenreich 92 (1928) 25.

Tacca angustilobata MERRILL in Philip. Journ. Sci. 29 (1926) 356.

PALAWAN (*Elmer 12659, Weber 1522*). Sulu Archipelago, Jolo, *Keinholz* s. n.; Tawitawi (*Warburg 14989*). British North Borneo, Banguey Island, *Castro and Melegrito 1398* (type of *Tacca angustilobata* Merrill) North Borneo (*Amdjah 950*).

This species is recorded chiefly in connection with the reduction of *Tacca angustilobata* Merrill, which, by comparison of descriptions, manifestly represents the same species at *Tacca elmeri* Krause.

TACCA VESICARIA Blanco.

Tacca vesicaria BLANCO, Fl. Filip. (1837) 261.

Tacca palmata BLANCO, Fl. Filip. ed. 2 (1845) 182, ed. 3, 1 (1877) 325; MERRILL, Interpret. Herb. Amb. (1917) 145, Sp. Blancoanae (1918) 100, Enum. Philip. Fl. Pl. 1 (1923) 214, non Blume.

Tacca rumphii SCHAUER in Nov. Act. Acad. Nat. Cur. 19 Suppl. 1 (1843) 442; LIMPRECHT in Pflanzenreich 92 (1928) 24.

Common and widely distributed in Luzon; also occurring in Celebes, Bouton, Amboina, and the Palau Islands.

Limprecht,[1] in his recent monographic treatment of this group, considers that *Tacca palmata* Blume is distinct from *T. rumphii* Schauer, confining the former to Java, Sumatra, and Nusa Kambangan, with a variety (*borneensis*) in Borneo. In this he is doubtless correct, but we cannot agree with him as to the specific name of the Philippine form, as he retains Schauer's *Tacca rumphii* of 1843, although Blanco's *T. vesicaria* antedates it by six years. Under all rules of nomenclature Blanco's specific name stands.

The form from Panay and the Calamian Islands (Coron) distributed by Merrill as *Tacca palmata* Blume, Limprecht [2] refers to *Tacca fatsiifolia* Warburg, a species otherwise known only from Celebes.

ZINGIBERACEÆ

Genus LANGUAS Koenig

LANGUAS PENDULA sp. nov. subgenus Probolocalyx.

Herba erecta; foliis chartaceis, breviter (usque ad 8 mm) petiolatis, oblongis, usque ad 52 cm longis, 15 cm latis, glabris, margine ciliatis, acute acuminatis, basi late acutis; ligula obtusa, biloba, circiter 6 mm longa, dense ciliata; racemis terminalibus, pendulis, laxis, multifloris, usque ad 35 cm longis; bracteis minutis, acutis, 1 ad 3 mm longis; rachis densissime pilosis; floribus fasciculatis, fasciculis remotis, pedicellis usque ad 22 mm longis; calycibus tubulosis, spathaceis, dense minute puberulis, 10.5 ad 11.5 mm longis, 4 ad 4.5 mm diametro, inaequaliter 3-lobatis, lobis 2 ad 4 mm longis; corollae tubo 9 ad 10 mm longo, extus

[1] Taccaceae. Pflanzenreich 92 (1928) 1–32, figs. 1–5.

[2] Op. cit. 23.

glabro, lobis extus minute puberulis, oblongis, obtusis, usque ad 10 mm longis, 4.5 mm latis, labellum obovatum, breviter bilobatum, margine dentatum, usque ad 8 mm longum, 6 mm latum; antheris planis, connectivi appendicula 0; ovarium glabrum; fructibus globosis, glabris, circiter 1.8 cm diametro.

An erect herb about 2 m high. Leaves chartaceous, shortly (5 to 8 mm) petiolate, oblong, 19 to 52 cm long, 6 to 15 cm wide, acutely acuminate, the base broadly acute, glabrous and almost gray on both surfaces, somewhat shining above, more or less glaucous beneath, margins ciliate; ligules coriaceous, obtuse, bilobed, about 6 mm long, densely ciliate. Racemes terminal, pendulous, lax, many-flowered, the flowering portion about 35 cm long, the peduncles 8.5 to 11.5 cm long; rachis very densely pilose; bracts minute, acute, 1 to 3 mm long. Flowers white, in rather remote 4- to 8-flowered fascicles, the pedicels up to 22 mm long, the upper ones shorter, about 5 mm long. Calyx tubular, spathaceous, densely and minutely puberulent outside, 10.5 to 11.5 mm long, 4 to 4.5 mm in diameter, unequally 3-lobed, the lobes triangular, acute, 2 to 4 mm long. Corolla exerted from the base of the calyx, glandular and glabrous inside, the tube 9 to 10 mm long, glabrous outside, the lobes oblong, obtuse, 7 to 10 mm long, 2 to 4.5 mm wide, minutely puberulent outside, the labellum obovate, recurved, shortly 2-lobed, the margins dentate, 7 to 8 mm long, 5 to 6 mm wide. Stamens 6 to 7 mm long; anthers plane, about 5 mm long, the cells minutely puberulent, the connective at the apex not enlarged. Ovary glabrous, globose; stigma obconic, ciliate. Fruits glabrous, globose, about 1.8 cm in diameter.

BOHOL, Sevilla, *Bur. Sci. 43328 Ramos* (type in the herbarium of the University of California), September 17, 1923, in thickets, altitude about 300 meters; Bilar, *Bur. Sci. 43174 Ramos*, September 9, 1923, in damp forests, altitude about 700 meters.

A species belonging in the group with *Alpinia orthostachys* K. Schumann, of Celebes, differing in its larger, broad, oblong leaves, large pendulous inflorescences, and its long pedicellate flowers.

LANGUAS SCORPOIDEA sp. nov. subgenus Dieramalpinia.

Herba erecta, circiter 2 m alta; foliis chartaceis, sessilibus, lanceolatis, 22 ad 34 cm longis, 2 ad 3.3 cm latis, utrinque glabris, apice attenuatis, acutis, basi rotundatis; ligula rotundata, circiter 1 mm longa; paniculis pedunculatis, terminalibus, scorpoideis, 11.5 ad 21.5 cm longis, cincinnis 3 ad 5, alternatim disposi-

tis, spicatis, sessilibus, scorpoideis, densis, 6 ad 12.5 cm longis, multifloris; bracteis bracteolisque persistentibus, perspicuis, apice ciliatis, bracteis cucullatis, lanceolatis, 2.5 ad 3.5 cm longis, bracteolis imbricatis, 1.5 ad 2.5 cm longis; floribus pedicellatis, campanulatis, 4 ad 4.5 cm longis, pedicellis pubescentibus, 2 ad 2.3 cm longis; calycibus tubulosis, spathaceis, 1.8 ad 2.2 cm longis, apice 2- vel 3-lobatis, lobis acutis, 4 ad 5 mm longis; corolla exerta, roseo-alba, tubo 1.5 ad 2 cm longo, lobis inaequalibus, majoribus late ovatis, rotundatis, usque ad 1.9 cm longis, 1.6 cm latis, lateralibus ovatis, obtusis, usque ad 1.8 cm longis, 1.3 cm latis; antheris oblongis, molliter pilosis, 1 ad 1.2 cm longis, connectivo breviter appendiculato, 1 mm longo; fructibus glabris, oblongo-obovoideis, usque ad 4 cm longis, 2.2 cm diametro.

An erect herb about 2 m high, the stems including the sheaths less than 1 cm in diameter. Leaves chartaceous, alternate, lanceolate, sessile, 22 to 34 cm long, 2 to 3.3 cm wide, the upper ones 12.5 cm long, 1.5 cm wide, narrowed to the slender acute apex, the base rounded, glabrous and shining on both surfaces, pale olivaceous-gray above, paler beneath; ligules chartaceous, rounded, about 1 mm long. Inflorescences terminal, pedunculate, scorpoid, 11.5 to 21.5 cm long; the cincinnæ 3 to 5, alternately arranged on the rachis, sessile, cylindric, dense, scorpoid, spicate, 6 to 12.5 cm long; bracts and bracteoles conspicuous, persistent, cucullate, lanceolate, glabrous except the pubescent tips, the bracts 2.5 to 3.5 cm long, the bracteoles 1.5 to 2.5 cm long; the pedicels densely black-pubescent, 2 to 2.3 cm long. Flowers numerous and crowded on the cincinnæ, campanulate, pinkish white, 4 to 4.5 cm long. Calyx in bud cylindric, lanceolate, acute, in anthesis tubular, spathaceous, 1.8 to 2.2 cm long, when spread about 1.5 cm wide at the middle, split about one-half to the base, the apex with 2 or 3 subequal acute teeth, 4 to 5 mm long, glabrous except the pubescent tips, 20- to 22-nerved. Corolla exerted, the tube 1.5 to 2 cm long, glabrous throughout except near the lobes, cylindric, somewhat enlarged upward and nearly 4 mm wide at the apex; the lobes unequal, sparsely and minutely puberulent outside, glabrous inside, the central one broadly ovate, rounded, 1.8 to 1.9 cm long, 1.3 to 1.6 cm. wide, the lateral ones ovate, obtuse, 1.7 to 1.8 cm long, 1 to 1.3 cm wide. Filaments stout, very much shorter than the anthers; anthers oblong, softly pilose, 1 to 1.2 cm long, 3.5 to 4 mm wide at the apex, the connective slightly crested, 1 mm long. Staminodes triangular, acute, densely and minutely puberulent,

about 2 mm long. Ovary sparsely puberulent, oblong-obovoid, 3-celled, 7 to 9 mm long, 3 to 3.5 mm in diameter; style filiform, softly pilose, 2.5 to 2.6 cm long; stigma clavate, pubescent. Fruit oblong-obovoid, somewhat angled, up to 4 cm long, 2.2 cm in diameter, glabrous. Seeds numerous, light reddish brown, smooth, with several faces, 3.5 to 4 mm long, about 3 mm in diameter.

MINDANAO, Davao Province, Mati, *Bur. Sci. 48947 Ramos and Edaño*, April 16, 1927, along streams in forests at low altitudes.

This species belongs in the subgenus *Dieralmalpinia* but we are uncertain to which of the described sections of Schumann it belongs. It is characterized by its scorpoid many-flowered inflorescences and its long, cylindric, dense spicate, sessile, conspicuously bracteate cincinnæ.

MORACEÆ

Genus FICUS Tournefort

FICUS CASIGURANENSIS sp. nov. § Covellia.

Arbor parva, circiter 5 m alta; ramulis dense hirsutis; foliis alternis, oblongo-obovatis, usque 29 cm longis, 14 cm latis, supra scaberrimis, subtus plus minusve hispidis, acuminatis, basi cordatis; petiolis usque 7 cm longis; receptaculis in ramis specialibus elongatis caulinis saltem 40 cm longis dispositis; receptaculis pedicellatis, fasciculatis, vel in ramulis brevibus dispositis, obovoideis, 1.2 ad 1.6 cm longis, extus dense ciliato-hirsutis.

A small tree, about 5 m high; the branchlets densely hirsute, with stiff, brown, long, straight hairs, terete or slightly angled, about 7 mm in diameter. Leaves alternate, long petiolate, equilateral, oblong-obovate, chartaceous, olivaceous, dull, 19 to 29 cm long, 10 to 14 cm wide, scabrous on both surfaces, especially on the upper, the midrib and nerves on both surfaces hirsute or hispid, shortly acuminate, base cordate, margins rather finely serrulate, lateral nerves 9 or 10 on each side of the midrib, prominent, reticulations distinct; petioles densely hirsute, 3.5 to 7 cm long; stipules lanceolate, acutely acuminate, chartaceous, cinereous, densely hirtellous except on the back below, 1.5 to 2 cm long. Inflorescence from the trunk, simple, either pendulous or spreading on the ground from the base of the tree, sometimes emitting rootlets, at least 40 cm long and probably much longer, the rachis 6 to 8 mm in diameter, rugose, nearly glabrous. Receptacles fascicled at the nodes or on stout lateral branches, 2 to 3 cm in length, obovoid, pedicellate, 1.2 to 1.6 cm long,

covered with dense, brown, stiff hairs; pedicels up to 7 mm long, densely hirsute, bracts 3 at the base of the receptacle, ovate, acute, about 3 mm long. Inside of the receptacle somewhat ciliate. Fertile female flowers pedicelled, their perianth segments probably abortive or early deciduous; pedicels about 1.5 mm in length, slightly ciliate at the base; ovary obovoid, about 0.5 mm in diameter; styles 0.75 to 1 mm in length.

LUZON, Tayabas Province, Casiguran, *Bur. Sci. 45343 Ramos and Edaño*, May 12, 1925, along streams in forests, at low altitudes.

A species belonging in the group with *Ficus kalingaensis* Merrill, but more pubescent, with cordate leaves and larger, densely hirsute receptacles.

URTICACEÆ

Genus BOEHMERIA Jacquin

BOEHMERIA MALABARICA (Wallich) Weddell.

Boehmeria malabarica (Wallich) WEDDELL in Arch. Mus. Hist. Nat. Paris 8 (1855–56) 355; DE CONDOLLE, Prodr. 16[1] (1869) 203; F.-VILLAR, Novis. App. (1880) 204.

Urtica malabarica WALLICH, Cat. No. 4610.

MINDANAO, Davao Province, Mati, *Bur. Sci. 48938 Ramos and Edaño*, April 15, 1927; Mayo (Bugak), *Bur. Sci. 49516 Ramos and Edaño*, May 23, 1927, along forested streams at low altitudes.

A species previously reported from the Philippines by Fernandez-Villar. It is doubtful whether or not he really had this form, and for this reason the species was not admitted as a Philippine one in Merrill's Enumeration of Philippine Flowering Plants 2 (1923) 91. India to Ceylon and Java.

Genus ELATOSTEMA Forster

ELATOSTEMA BOHOLENSIS sp. nov.

Herba dioica, caulis deorsum prostratis, hirtellis, angulatis, haud vel parce ramosis; foliis subsessilibus, membranaceis, linearis, 2.7 ad 5.7 cm longis, 0.4 ad 0.7 cm latis, subtus in siccitate fuscis, ad costa nervisque hirtellis, supra olivaceis, cystolithis numerosis instructis, apice attenuatis, subacutis, basi inaequilateralis uno latere anguste rotundatis altero auriculatis, margine undulatis; receptaculis ♀ sessilibus, solitariis, 3 ad 5.5 mm diametro.

Stems simple or sparingly branched, prostrate below, 26 to 37 cm long, the younger ones especially densely hirtellous, slen-

der, 1 to 2 mm in diameter, somewhat angled. Leaves subsessile, membranaceous, narrowly linear, 2.7 to 5.7 cm long, 0.4 to 0.7 cm wide, apex subacute, base inequilateral, narrowly rounded on one side, auriculate on the other, margins undulate, the upper surface olivaceous, supplied with numerous cystoliths, glabrous, the lower surface brown, densely hirtellous on the costa and nerves; lateral nerves somewhat prominent, distant, spreading at right angles, 12 to 20 on each side of the midrib; petioles very short, 1 to 2 mm long; stipules membranaceous, linear, acuminate, 3 to 3.5 mm in length. Pistillate receptacles sessile, solitary, 3 to 5.5 mm in diameter, the outer pairs of bracts fused in the basal half or free only near their apices, oblong, subpellucid, 3 to 3.25 mm long, the next pair of bracts triangular-ovate, acute, ciliate on the back and on the margin, 1.5 to 2.5 mm long; bracteoles lanceolate, acute, about 2 mm long, ciliate; flowers very shortly pedicellate, perianth lobes 3, very minute; achene oblong, about 0.5 mm in length.

BOHOL, Valencia, *Bur. Sci. 43093 Ramos*, (type in the herbarium of the University of California; isotype in the herbarium of the Bureau of Science, Manila), October 3, 1923, in damp forests, altitude about 600 meters.

The species has considerable resemblance to *Elatostema angustatum* Merrill, but differs in its pubescent stem, in its leaves with auriculate bases, the margins undulate, not serrate, and with numerous cystoliths on the upper surface.

OLACACEÆ

Genus ERYTHROPALUM Blume

ERYTHROPALUM TRIANDRUM sp. nov.

Frutex scandens, inflorescentiis parce pubescentibus exceptis glaber; foliis ovatis ad oblongo-ovatis, chartaceis ad subcoriaceis, usque ad 16.5 cm longis, 9 cm latis, acute acuminatis, basi subacutis ad subcordatis, supra nitidis; inflorescentiis laxis, usque ad 35 cm longis; bracteis subulatis, circiter 1 mm longis, bracteolis minutis; floribus dioiceis, 6 ad 7 mm longis, pedicellis minute puberulis; calycibus glabris, obscure 4- vel 5-denticulatis, 3 ad 3.5 mm longis; corolla glabra, profunde 5-lobata, lobis oblongo-lanceolatis, acutis, 5 ad 6.5 mm longis; staminibus 3, antheris oblongis, circiter 3 mm longis; filamentis circiter 1.5 mm longis; staminoideis 0.

A scandent shrub, the branches subterete, glabrous, canaliculate, about 2 mm in diameter. Leaves ovate to oblong-ovate,

chartaceous to subcoriaceous, 9 to 16.5 cm long, 4 to 9 cm wide, narrowed to the acutely acuminate apex, the base subacute to subcordate, the younger ones pale reddish brown, the older ones straw-colored, glabrous on both surfaces, shining on the upper surface, nerves 5 to 7 on each side of the midrib, the lower ones originating from the base of the midrib, prominent, ascending; petioles 1.5 to 2 cm long; tendrils bifid. Inflorescence axillary, lax, many-flowered, up to 37 cm long, the peduncle 2.5 to 6.5 cm long, glabrous; branchlets minutely puberulent; bracts subulate, about 1 mm long. Flowers apparently diœcious, pale brown, 6 to 7 mm long; bracteoles minute; the pedicels minutely puberulent, slender, 1.5 to 4 mm long. Calyx glabrous, obconic, obscurely 4- or 5-toothed, 3 to 3.5 mm long, 5 to 6 mm in diameter. Corolla glabrous, deeply 5-parted, the lobes erect, fleshy, oblong-lanceolate, acute, 5 to 6.5 mm long. Stamens 3; anthers oblong, about 3 mm long, 1.5 to 1.75 mm in diameter; filaments flattened, about 1.5 mm long, glabrous. Staminodes 0.

MINDANAO, Davao Province, Mati, *Bur. Sci. 49096 Ramos and Edaño*, March 26, 1927, along forested streams at low altitudes.

This unique species has the vegetative characters of *Erythropalum scandens* Blume but transcends the limits of the genus as at present defined in its floral characters. It is strongly characterized by the presence of three stamens only and the absence of staminodes. It may perhaps represent a new generic type near *Erythropalum*, but in the absence of female flowers it has been thought best to place it here.

MYRISTICACEÆ

Genus KNEMA Loureiro

KNEMA CENABREI sp. nov. Plate 3.

Arbor circiter 16 m alta, ramulis dense breviter ferrugineo-pubescentibus, ramis glabris vel subglabris; foliis oblongis, subcoriaceis, 15 ad 24 cm longis, 3 ad 6 cm latis, apice acuminatis, basi plerumque rotundatis, supra glabris, nitidis, olivaceus, subtus glaucis, glabris vel junioribus deorsum ad costa nervisque decidue ferrugineo-pubescentibus, nervis utrinque 21 ad 28; floribus ♂ numerosis, fasciculatis, axillaribus et in axillis defoliatis, 4 ad 6 mm diametro, extus dense ferrugineo-pubescentibus, intus glabris, pedicellis quam floribus duplo longioribus; disco stamineo unbonato, sessile, circiter 2 ad 3 mm diametro; antheris 12 ad 16 ferentibus.

A tree about 16 m high, the branches glabrous, pale brown, terete, about 4 mm in diameter, the branchlets densely ferruginous-pubescent, 2 to 3 mm thick. Leaves oblong, subcoriaceous, 15 to 24 cm long, 3 to 6 cm wide, acuminate, base mostly rounded, the upper surface olivaceous, shining, glabrous, the lower surface brownish, glaucous, glabrous, or the midrib in the lower part and the lower nerves more or less pubescent with ferruginous deciduous hairs; lateral nerves 21 to 28 on each side of the midrib, very prominent on the lower surface, curved toward the margin, the primary reticulations slender, subparallel; petioles densely ferruginous-pubescent when young, becoming glabrous in age, 8 to 14 mm long. Staminate flowers more or less obovoid, axillary, and in the axils of fallen leaves, 8 to 14 in a fascicle, brown, 4 to 6 mm in diameter, together with the 5- to 9-mm-long pedicels, densely ferruginous-pubescent; perianth lobes orbiculate-ovate, inflexed, about 3 mm long, pubescent without, glabrous within; staminal disk sessile, umbonate, 2 to 3 mm in diameter, bearing from 12 to 16 0.5-mm-long anthers radiating from the margin.

PALAWAN, Dumaran Island, *For. Bur. 29973 Cenabre*, July 28, 1925, in damp forests at low altitudes, along Linuatan Creek; local name, *dago manok* (Cuy.).

A species apparently most closely allied to the Bornean *Knema korthalsii* Warburg, from which it is distinguished by its umbonate staminal disk and in its more-numerous stamens.

MONIMIACEÆ

Genus MATTHAEA Blume

MATTHAEA HETEROPHYLLA sp. nov.

Frutex glaber; ramulis laevis; foliis oblongo-ellipticis ad oblongo-lanceolatis, 9 ad 16 cm longis, 2.4 ad 4.5 cm latis, acute acuminatis, basi acutis, subcoriaceis, integris, utrinque glabris nitidisque; nervis lateralibus utrinque 8 ad 10; infructescentiis terminalibus, pedunculatis, pedunculis 1.8 ad 2 cm longis, subglabris ad sparse pubescentibus; receptaculis coriaceis, pubescentibus; drupis ellipsoideis, nitidis, nigris, glabris vel parsissime pubescentibus, 1.8 ad 2.2 cm longis, 1 ad 1.6 cm diametro; pedicellis glabris vel parsissime pubescentibus, 0.8 ad 1.3 cm longis.

A shrub, the branches terete, pale, glabrous, the branchlets glabrous or the ultimate ones sparingly pubescent with short

yellowish white hairs. Leaves elliptic-oblong to oblong-lanceolate, opposite, 9 to 16 cm long, 2.4 to 4.5 cm wide, acutely acuminate, base acute, subcoriaceous, entire, glabrous except the very young leaves which are very sparsely pubescent on both surfaces with short, scattered, yellowish white hairs, shining on both surfaces, pale olivaceous above, light brown beneath; lateral nerves 8 to 10 on each side of the midrib, obscure above, distinct beneath, spreading, uniting directly with the arched marginal nerves; petioles 1.3 to 2 cm long. Infructescence terminal, pedunculate; the peduncles 1.8 to 2 cm long, subglabrous to very sparsely pubescent; receptacles coriaceous, pubescent with yellowish hairs, 0.9 to 1.1 cm in diameter. Drupes ellipsoid, shining, black, glabrous, or near the base sparsely pubescent, 1.8 to 2.2 cm long, 1 to 1.6 cm in diameter; pedicels glabrous or very sparsely pubescent, 0.8 to 1.3 cm long.

LUZON, Isabela Province, Mount Moises, *Bur. Sci. 47318 Ramos and Edaño,* March 3, 1926, on forested slopes, altitude about 1,200 meters.

This characteristic species is manifestly allied to *Matthaea ellipsoidea* Merrill, from which it is distinguished by its entire leaves, pubescent ultimate branchlets and very young leaves, smaller drupes, longer pedicels, and pubescent receptacles.

Bur. Sci. 47089 Ramos and Edaño from San Mariano, Isabela Province, Luzon, probably represents a form of the same species, differing in its larger leaves, 17 to 31 by 4.5 to 6.5 cm, and axillary infructescences.

LAURACEÆ

Genus ALSEODAPHNE Nees

ALSEODAPHNE LONGIPES sp. nov.

Arbor parva, usque ad 8 m alta, glabra, ramis teretibus, pallidis; foliis crasse coriaceis, pseudoverticillatim confertis, oblanceolatis ad oblongo-ellipticis vel oblongo-obovatis, obtusis ad acuminatis, basi acutis, supra nitidis, subtus glaucis, 10.5 ad 24 cm longis, 3 ad 7 cm latis, nervis lateralibus utrinque 10 ad 14, subtus valde perspicuis, utrinque subfoveolato-reticulatis; petiolo 1 ad 2.5 cm longo; inflorescentiis 9 ad 14.5 cm longis, pedunculatis; floribus paucis, subumbellatis, 3 ad 3.5 mm longis; segmentis extus glabris, intus pubescentibus; staminoideis 3, pubescentibus, 1 ad 1.25 mm longis; ovario globoso, glabro; fructibus globosis ad obovoideo-globosis, glabris, 1.5 ad 2 cm longis, 1.6 ad 2.5 cm diametro, pedicellis sub fructu incrassatis, verrucosis, 2 ad 4.5 cm longis.

A small tree, up to 8 m high, glabrous throughout except the flower parts, the branches terete, pale. Leaves pseudoverticellately crowded at the top, thickly coriaceous, oblanceolate to oblong-elliptic or oblong-obovate, obtuse to acuminate, base acute, when dry shining and light brown above, glaucous beneath, 10.5 to 24 cm long, 3 to 7 cm wide; lateral nerves 10 to 14 on each side of the midrid, very prominent beneath, impressed above, both surfaces rather densely subfoveolate-reticulate; petioles thick, 1 to 2.5 cm long, sulcate above. Panicles in the upper axils, 9 to 14.5 cm long, glabrous; their peduncles 5 to 8.5 cm long. Flowers few, creamy yellow, odorless, subumbellate, 3 to 3.5 mm long, the pedicels slender, 4.5 to 5 mm long, glabrous; perianth segments 6, equal, or the outer ones smaller, glabrous outside, pubescent inside, the three outer ones ovate, 1.75 to 2 mm long, 1 to 1.3 mm wide, the three inner ones oblong-ovate to ovate-lanceolate, 2.5 to 3 mm long, 1 to 1.25 mm wide; stamens 9, perfect, in three rows, six of the outer two rows 1.5 to 2.1 mm long, eglandular, introrse, three of the innermost row, 1.75 to 2.25 mm long, glandular, extrorse, the 2 basal glands, minute, 0.5 to 1 mm long; anthers 4-celled; filaments longer than the anthers, pubescent at the base; staminodes 3, prominent, pubescent, 1 to 1.25 mm long, about 0.8 mm in diameter, stipitate, ovate; ovary globose, glabrous. Drupe red when fresh, dark brown to black when dry, globose to obovoid-globose, 1.5 to 2 cm long, 1.6 to 2.5 cm in diameter, their pedicels thickened, reddish brown, verrucose, 2 to 4.5 cm long, 0.5 to 0.8 cm in diameter when dry, the perianth segments early deciduous.

MINDANAO, Agusan Province, Urdaneta, Cabadbaran, *Elmer 13962* (type), *13400*, October, 1912, on steep slopes, altitude about 1,000 meters, known locally as *magyan-tawan* (Mbo.). LUZON, Isabela Province, Mount Moises, *Bur. Sci. 47317 Ramos and Edaño*, March 4, 1926, *Clemens 16900*, April, 1926, along forested streams, altitude about 970 meters: Nueva Vizcaya Province, Mount Alzapan, *Bur. Sci. 45630 Ramos and Edaño*, May 21, 1925, on forested slopes, altitude about 1,700 meters: Caraballo Mountains, *Loher 13756*, March, 1915: Benguet Subprovince, Tanit, *For. Bur. 29387 Lizardo*, August 18, 1923.

The genus, which extends from southeastern China, Borneo, Java, and the Malay Peninsula to Ceylon, is new to the Philippines. This well-marked species may be placed near *Alseodaphne insignis* Gamble, but differs in its vegetative and fruit characters. Elmer's specimens were erroneously distributed as *Persea philippinensis* Merrill.

Genus CINNAMOMUM Blume

CINNAMOMUM MICROPHYLLUM sp. nov. § **Malabathrum.**

Arbor parva, ramulis et foliis junioribus et inflorescentiis dense molliter griseo-pubescentibus; foliis numerosis, confertis, coriaceis, oblongo-ellipticis, 2.5 ad 5 cm longis, 0.8 ad 1.8 cm latis, supra nitidis, obtuse acuminatis, basi acutis, 3-plinerviis; paniculis paucifloris, axillaribus, 3.5 ad 5 cm longis; floribus pedicellatis, 3 ad 4 mm longis; staminibus 2 ad 2.25 mm longis, filamentis quam antheris duplo longioribus, pubescentibus; staminoideis stipitatis, pubescentibus, 1 ad 1.5 mm longis; ovario glabro, obovoideo.

A small tree, the younger branchlets, the lower surface of the leaves and inflorescences densely and softly cinereous-pubescent, the very old leaves glabrous on both surfaces, the young ones more or less pubescent above; branches terete, glabrous, somewhat rugose, 4 to 6 mm in diameter. Leaves small, numerous, crowded on the branchlets, coriaceous, oblong-elliptic, 2.5 to 5 cm long, 0.8 to 1.8 cm wide, obtusely acuminate, base acute, the upper surface smooth and shining, the lower rather dull, base 3-plinerved, the nerves very prominent on the lower surface, not prominent on the upper surface; petioles 3 to 6 mm long, densely pubescent when young, in age glabrous. Panicles axillary, 3.5 to 5 cm long, few-flowered, rather densely and softly gray-pubescent, their peduncles very slender, 2.4 to 3.5 cm long; flowers pedicellate, 3 to 4 mm long, 3.25 to 3.5 mm in diameter; externally very densely pubescent; perianth lobes oblong-obovate, subacute, 2.5 to 2.75 mm long, 1.5 to 1.75 mm wide; stamens 2 to 2.25 mm long; filaments densely pubescent, twice as long as the ovoid anthers; staminodes stipitate, oblanceolate, acute, densely pubescent, 1 to 1.5 mm long; ovary glabrous, obovoid; style 1.25 to 1.5 mm long.

LUZON, Tayabas Province, Mount Alzapan, *Bur. Sci. 45692 Ramos and Edaño*, June 7, 1925, in the mossy forest, altitude about 1,900 meters.

A characteristic species readily recognizable by its small, crowded, pubescent, oblong-elliptic leaves, and short, few-flowered, pubescent inflorescences.

CINNAMOMUM TRICHOPHYLLUM sp. nov.

Arbor parva, ramis et subtus foliis et inflorescentiis densissime molliter pubescentibus; foliis subcoriaceis, oblongo-ellipticis, 10.5 ad 21.5 cm longis, 3.5 ad 8 cm latis, supra nitidis, acute

acuminatis, basi acutis, perspicue 3-nerviis ad 3-subplinerviis; paniculis paucifloris, terminalibus, 7 ad 9.5 cm longis; floribus pedicellatis, 3.5 ad 3.75 mm longis; staminibus circiter 2 mm longis, filamentis quam antheris longioribus, pubescentibus; staminoideis stipitatis, pubescentibus, circiter 1.5 mm longis, sagittatis; ovario glabro, obovoideo; fructibus ellipsodeis, nigrescentibus, glabris, circiter 10 mm longis, 8 mm diametro, calycibus haud incrassatis, paullo accrescentibus.

A small tree, the branches, branchlets, the lower surface of the leaves, and the inflorescences very densely and softly pubescent with pale cinereous to golden-yellow hairs; branches terete, about 3.5 mm in diameter. Leaves subcoriaceous, oblong-elliptic, 10.5 to 21.5 cm long, 3.5 to 8 cm wide, acutely acuminate, base acute, the upper surface smooth, shining, pale olivaceous-brown, the lower surface of nearly the same color, base prominently 3-nerved to 3-subplinerved; petioles very densely pubescent, 6 to 9 mm long. Panicles terminal, few-flowered, 7 to 9.5 cm long, densely and softly gray to golden-yellow pubescent, their peduncles slender, 2 to 5 cm long. Flowers pedicellate, 3.5 to 3.75 mm long, 3 to 3.5 mm in diameter, the pedicels 4 to 5 mm long; perianth lobes oblong-ovate, subacute, densely pubescent on both surfaces, 2.5 to 2.75 mm long, about 1.5 mm wide. Stamens about 2 mm long, the filaments pubescent, very slender, slightly longer than the ovoid anthers; staminodes stipitate, about 1.5 mm long, sagittate, the stalk densely pubescent, very slender. Ovary glabrous, obovoid; style about 1.25 mm long. Fruits ellipsoid, rounded, black, glabrous, about 10 mm long, 8 mm in diameter; the persistent pubescent perianth never thickened and but slightly enlarged.

MINDANAO, Davao Province, Limot, *Bur. Sci. 49530 Ramos and Edaño,* May 26, 1927, on slopes in the primary forest, altitude about 700 meters.

A species resembling *Cinnamomum mollissimum* Hooker f. in its vegetative appearance, differing radically in its pubescent perianth, which is not thickened and is but slightly accrescent in fruit; differing, also, in its very slender filaments and sagittate staminodes.

HERNANDIACEÆ

Genus ILLIGERA Blume

ILLIGERA OVATIFOLIA sp. nov. § Parviglandulatæ.

Frutex scandens, inflorescentiis exceptis glaber; ramis angulatis, laevis; ramulis striatis; foliis trifoliolatis, petiolo 6 ad 10

cm longo; foliolis 9 ad 15 cm longis, 5.5 ad 9 cm latis, ovatis vel late oblongo-ovatis, apice subabrupte acuminatis, basi rotundatis ad subcordatis, nitidis, chartaceis ad subcoriaceis, nervis lateralibus utrinque 6 vel 7, perspicuis; inflorescentiis paniculatis, laxis, pendulis, 5.5 ad 19 cm longis; floribus 4 ad 5 mm longis, pedicellis puberulis, 1 ad 2 mm longis; calycibus extus puberulis, lobis oblongis vel ovato-lanceolatis, subacutis, 3 ad 4 mm longis; petalis oblongo-ellipticis, extus glabris, intus pubescentibus, circiter 4 mm longis. Fructibus glabris, cum aliis 3.7 ad 4 cm longis, 6.8 ad 8.2 cm latis.

Scandent, the branches angled, smooth, glabrous, about 5 mm in diameter, the branchlets smooth, striate, glabrous except at the nodes, which are more or less pubescent with yellowish, soft, short hairs. Leaves 3-foliolate, their petioles glabrous, 6 to 10 cm long; leaflets 9 to 15 cm long, 5.5 to 9 cm wide, ovate or broadly oblong-ovate, subabruptly acutely to obtusely acuminate, base rounded to subcordate, glabrous and shining on both surfaces, chartaceous to subcoriaceous; lateral nerves 6 or 7 on each side of the midrib, anastomosing, prominent beneath, somewhat impressed above, the reticulations lax, prominent beneath; petiolules 1.5 to 2.7 cm long, the central one usually longer. Panicles pendulous, lax, 5.5 to 19 cm long, subglabrous, the branches scattered, 4.5 to 7.5 cm long. Flowers 4 to 5 mm long, their pedicels densely pubescent, slender, 1 to 2 mm long; bracteoles ovate-lanceolate, puberulent, 1.5 to 2.25 mm long; calyx tube about 1 mm long, pubescent, the lobes 5, oblong to ovate-lanceolate, subacute and somewhat inflexed at the apex, 3 to 4 mm long; petals 5, oblong-elliptic, subacute, yellowish green, glabrous outside, except near the apex, pubescent inside, about 4 mm long, 1.5 to 1.75 mm wide; stamens 5, equal, about 2.75 mm long, anthers erect, oblong, subobtuse, connective rather stout, about 1.75 mm long, filaments somewhat compressed, glabrous, the nectarine glands minute, sessile, subglobose, carrying on each side near the base a staminode up to 1 mm long; style filiform; stigma subpeltate, somewhat dilated, lobed. Fruits glabrous, shining, including the wings 3.7 to 4 cm long, 6.8 to 8.2 cm wide, two wings broadly rounded, the other two reduced to keels.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 46712* (type), *47166, Ramos and Edaño*, February 24, 1926, *Clemens 16717*, August, 1926. Along streams in damp forests, altitude 300 to 600 meters.

This species is apparently allied to *Illigera pulchra* Blume, from which it may be distinguished by its very differently shaped leaves, which are ovate or broadly oblong-ovate; the oblong-elliptic, larger petals; glabrous filaments; and much larger fruits.

LEGUMINOSÆ

Genus BAUHINIA Linnæus

BAUHINIA CHALCOBAPTA sp nov. § **Phanera.**

Frutex scandens, inflorescentiis et ramulis et subtus foliis exceptis glaber; foliis suborbiculariovatis, 5.3 ad 7.7 cm longis, 4 ad 6 cm latis, subcoriaceis, 11- ad 13-nerviis, basi cordatis, apice 2-lobatis, lobis oblongis, obtusis; floribus circiter 4.5 cm longis, pedicellis pubescentibus, 1.5 ad 2.5 cm longis; calycis tubo elongato, cylindrico, 1.3 ad 1.5 cm longo, circiter 3 mm diametro, lobis lineari-suboblanceolatis, acuminatis, 1.5 ad 2 cm longis; petalis subinaequalibus, extus cupreo-tomentosis, intus glabris, obovato-lanceolatis, obtusis, 2.7 ad 3.2 cm longis; staminibus 3; ovario styloque dense pubescenti.

A scandent shrub, the branches terete, pale, glabrous; leaves suborbicular-ovate, 5.3 to 7.7 cm long, 4 to 6 cm wide, subcoriaceous, the upper surface light brown, shining, glabrous, the lower surface paler, with very short, shining, appressed yellowish hairs, 2-lobed, the lobes oblong, obtuse, extending about one-third to the base, sinus narrow, the base slightly cordate, 11- to 13-nerved, the nerves prominent; petioles slender, pubescent, 1.5 to 2.3 cm long. Racemes terminal, densely pubescent, 4 to 7.5 cm long; flowers up to 14 in each raceme, about 4.5 cm long, greenish yellow, their pedicels pubescent, 1.5 to 2.5 cm long, the subtending bracteoles pubescent, ovate-lanceolate, up to 6 mm in length; calyx tube cylindric, slightly narrowed below, 1.3 to 1.5 cm long, about 3 mm in diameter, pubescent, the lobes 5, suboblanceolate, acuminate, pubescent externally, 1.5 to 2 cm long 3.5 to 4.25 mm wide; petals subequal in length, densely cupreo-tomentose externally, glabrous within, obovate-oblanceolate, obtuse, 2.7 to 3.2 cm long, 0.7 to 1.3 cm wide; fertile stamens 3, the anthers oblong-elliptic, 7 to 8 mm long, filaments 2.7 to 2.9 cm long, slender; ovary and style very densely pubescent with appressed short cupreous hairs.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 47217 Ramos and Edaño*, March 26, 1926, along streams in open forests, altitude about 650 meters.

A species apparently allied to *Bauhinia warburgii* Perkins, but with smaller leaves, pubescent petioles, and much shorter calyx tubes and lobes.

Genus MUCUNA Adanson

MUCUNA PLATYPLEKTA sp. nov. § **Zoopthalmum, Citta.**

Frutex scandens, perspicue pubescentibus; foliolis chartaceis, supra glabris, subtus adpresse pubescentibus, late ovatis ad elliptico-ovatis, lateralibus obliquis, 12.2 ad 15.5 cm longis, 8.5 ad 11 cm latis, breviter acuminatis, nervis lateralibus utrinque 7, perspicuis; racemis sub fructu, circiter 15 cm longis; fructibus oblongis, obtusis, circiter 12 cm longis, 6 ad 6.5 latis, 2 ad 2.5 cm crassis, ferrugineo-hirsutis, valvis profunde subobliquo lamellatis, lamellis usque ad 15, 8 ad 13 mm altis, crasis, latis, rigidis, plerumque fissis, pilis rigidis urentibus instructis; seminibus plerumque 3, ellipticis, nitidis, leviter compressis, 2.4 ad 2.6 cm longis, 1.8 ad 2.2 cm latis.

A woody vine, prominently pubescent except the upper surface of the leaflets and the older branches, the branches terete, dark brown, 3.5 to 5 mm in diameter. Petioles 10 to 11.5 cm long, densely pubescent with soft, appressed, short yellowish white hairs. Leaflets chartaceous, densely clothed with appressed short yellowish white hairs beneath, the terminal leaflets broadly elliptic-ovate, very shortly blunt acuminate, base broadly acute, about 12 cm long, 8.5 to 11 cm wide, lateral nerves 7 on each side of the midrib, very prominent, reticulations somewhat obscure, petiolules 3 to 3.4 cm long, the lateral leaflets oblique, broadly ovate, base inequilateral, one side very broadly rounded, 12.5 to 15.5 cm long, 9 to 11 cm wide, petiolules 0.6 to 1 cm long. Racemes in fruit about 15 cm long including the 4-cm-long peduncle, densely pubescent with soft, appressed, short yellowish white scars, up to 22 in each inflorescence. Pods about 12 cm long, 6 to 6.5 cm wide, 2 to 2.5 cm thick, oblong, obtuse, the sutures broad, channeled, winged, the wings connected directly with the transverse lamellæ, the faces traversed by close, double, somewhat oblique, rigid plaits; the plaits broad, 8 to 13 mm deep, bearing numerous, rigid, ferruginous, stinging bristles; pedicels 2 to 2.8 cm long, the calyx, which is sometimes persistent on the mature fruits, densely pubescent on both surfaces, about 1.5 cm long, 1.5 cm in diameter, the lower teeth linear, about 5 mm long, the lateral and upper segments very short and deltoid.

Seeds usually 3, smooth and shining, elliptic, and slightly compressed, 2.4 to 2.6 cm long, 1.8 to 2.2 cm wide, 1 to 1.2 cm thick.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 47232 Ramos and Edaño* (type), February 16, 1926, along streams at low altitudes; *Clemens 17050*, August, 1926, in dry open forests.

A species manifestly allied to *Mucuna biplicata* Teysmann and Binnendijk, differing in its pubescent leaves and larger pods, with broader plaits.

Genus RHYNCHOSIA Loureiro

RHYNCHOSIA MYRIOCARPA sp. nov. § Eurhynchosia.

Frutex scandens, pubescente; foliolis ovatis ad late ovatis, 4 ad 10.5 cm longis, 3.5 ad 8.5 cm latis, breviter obtuse acuminatis, basi rotundatis, chartaceis, eglandulosis, stipellatis, utrinque pilosis; racemis multifloris, quam foliis longioribus, 12 ad 15 cm longis; floribus pallide violaceis, calycibus lobis acutis, inaequalibus; fructibus dense pilosis, 1.7 ad 2 cm longis.

A scandent pubescent shrub, the stems terete, canaliculate, pilose, 1.5 to 2.5 mm in diameter. Stipules lanceolate, caducous, about 5 mm long. Petioles densely pilose, slender, canaliculate, 3.5 to 6 cm long; leaflets chartaceous, eglandular, pilose on both surfaces, stipellate, short and obtusely acuminate, base rounded, the lateral ones smaller, ovate, base inequilateral, 4 to 9 cm long, 3.5 to 6 cm wide, the petiolules 3 to 4 mm long, the central ones broadly ovate, base equilateral, 5.5 to 10.5 cm long, 5 to 8.5 cm wide, long-stalked, 1.5 to 3 cm long. Racemes 12 to 15 cm long, the peduncles 1.5 to 2 cm long; bracts conspicuous, subulate, about 5 mm long. Flowers 40 to 80 on each raceme, 11 to 13 mm long, their pedicels very slender, pubescent, 4 to 5 mm long. Calyx densely pubescent, about 5 mm long, the lobes unequal, acute, up to 2 mm long. Corolla pale violet, pubescent on the outside, twice as long as the calyx. Stamens glabrous. Ovary densely pilose. Pods greenish, densely pilose, somewhat compressed, 1.7 to 2 cm long, 6 to 6.5 mm wide. Seeds 2 in each pod, black, shining, without an aril, about 4.5 mm long, 3.5 to 4 mm wide.

MINDANAO, Davao Province, Mati, *Bur. Sci. 48984* (type), *Ramos and Edaño*, April 17, 1927; Tambungan, *Bur. Sci. 48972 Ramos and Edaño*, April 31, 1927, in the open places at low altitudes.

This species is distinguished by its densely pubescent pods, long, many-flowered racemes, and its eglandular leaves.

RUTACEÆ

Genus CLAUSENA Burman f.

CLAUSENA LAXIFLORA sp. nov.

Frutex 3 ad 4 m altus, vix aromaticus, glaber vel subglaber; foliis usque ad 39 cm longis, foliolis 7 ad 9, membranaceis, usque ad 16 cm longis, 6.5 cm latis, ovatis ad ellipticis, inaequilateralibus, obtusis; paniculis laxis, 30 ad 35 cm longis, leviter pubescentibus; floribus 5-meris, circiter 5 mm diametro.

A shrub 3 to 4 m high, glabrous except the slightly puberulent younger parts and the inflorescence, scarcely aromatic. Branches terete, brownish green. Leaves 26 to 39 cm long, the petioles and rachis minutely puberulent, becoming glabrous; leaflets 7 to 9, alternate, ovate to elliptic, the larger ones up to 16 cm long, 6.5 cm wide, the basal ones smallest, about 4 cm long and 2.5 cm wide, those on the upper part of the rachis larger and longer than the lower ones, membranaceous, the basal ones sometimes subchartaceous, strongly inequilateral, very shallowly and irregularly undulate-crenate, obtusely acuminate, base rounded to acute, pale olivaceous-brown to brown above, paler beneath, or of about the same color on both surfaces when dry, shining; lateral nerves 7 to 9 on each side of the midrib, prominent, distant, irregular, anastomosing, the reticulations somewhat obscure, lax; petiolules slender, 3 to 5 mm long. Panicle terminal, pyramidal, lax, 30 to 35 cm long, minutely puberulent, the lower branches 17 to 22 cm long, the upper gradually shorter. Flowers numerous, 5-merous, the pedicels minutely puberulent, about 2 mm long. Buds globose-ovoid. Bracts triangular, about 0.1 mm long. Calyx shallow, 1.5 mm in diameter, 5-lobed, the lobes broadly ovate, acute, glabrous, margins sparsely and minutely puberulent. Petals 5, imbricate, oblong, obtuse, 3.75 to 4 mm long, 2 to 2.5 mm wide, glandular, glabrous. Stamens 10, about 3 mm long; anthers oblong, apiculate, about 1.5 mm long; filaments somewhat enlarged below. Ovary globose, glabrous.

MINDANAO, Davao Province, Mati, *Bur. Sci. 48983* (type), *49087 Ramos and Edaño*, April 27, 1927 and March 27, 1927, respectively, in damp forests at low altitudes.

A species characterized by its lax inflorescences and large, membranaceous leaflets.

BURSERACEÆ

Genus CANARIUM Linnæus

CANARIUM OXYGONUM sp. nov.

Arbor parva; ramulis incrassatis, perspicue lenticellatis, glabris, circiter 2 cm diametro; foliis usque ad 50 cm longis, 6-jugis; foliolis usque ad 31 cm longis, 9.5 cm latis, coriaceis, nitidis, oblongo-ellipticis, distincte caudato-acuminatis, basi rotundatis, integris, supra glabris, subtus ad costa nervisque breviter puberulis, nervis lateralibus utrinque 16 ad 20, adcendentibus, subtus valde perspicuis, reticulis perspicuis; infructescentiis racemosis, usque ad 17 cm longis; fructibus ovoideis, acutis, rugosis, acute 3-angulatis, circiter 4.3 cm longis, 3 cm diametro.

A small tree, the ultimate branchlets stout, prominently lenticellate, reddish brown, wrinkled when dry, about 2 cm in diameter, the very tip above the leaves, densely ferruginous-pubescent. Leaves more or less crowded toward the ends of the branchlets, up to 50 cm long, each with 13 leaflets, the rachis and petiole rather stout, shining, striate; stipules none or very early deciduous. Leaflets opposite, the lowest ones ovate and much smaller, 7 to 12 cm long, 4 to 5.5 cm wide, the intermediate and upper ones oblong-elliptic, up to 31 cm long, 9.5 cm wide, shining on both surfaces, glabrous above, sparsely puberulent on the midrib and nerves beneath, brown above, darker beneath, coriaceous, distinctly caudate-acuminate, base equilateral or inequilateral, rounded; lateral nerves of the median leaflets 16 to 20 on each side of the midrib, of the lower ones about 10, very distinct on the lower surface, ascending, curving, the reticulations prominent on both surfaces; petiolules stout, 5 to 10 mm long, in the terminal leaflet up to 5 cm long. Flowers not seen. Infructescence in the upper axils, racemose, up to 17 cm long, densely ferruginous-pubescent, the persistent calyx 3-lobed, very coriaceous, about 10 mm in diameter, densely pubescent with short hairs outside, and covered with setose hairs inside, the lobes broadly ovate; pedicels stout, short. Fruit ovoid, acute, about 4.3 cm long, 3 cm in diameter, with 3 acute angles, the pericarp apparently fleshy, slightly wrinkled, glabrous, the endocarp bony, 3-celled, somewhat obtuse at both ends, with 3 prominent acute angles, and with 3 intermediate, shallow, acute ridges which do not unite at the apex and are evanescent near the base.

LUZON, Tayabas Province, Mount Alzapan, *Bur. Sci. 45723 Ramos and Edaño*, June 6, 1925, on forested slopes, altitude about 1,900 meters. Local name, *kagusikes* (Tag.).

A species apparently allied to *Canarium nervosum* Elmer, differing in its larger fruits with three acute angles, its puberulent leaflets, and the sculpture of the endocarp.

MELIACEÆ

Genus AGLAIA Loureiro

AGLAIA CAULOBOTRYS sp. nov. § Euaglaia.

Arbor parva, partibus junioribus inflorescentiisque castaneo-stellato-pubescentibus; foliis usque ad 70 cm longis, foliolis 11 ad 13, oblongis, usque ad 25 cm longis et 9 cm latis, subcoriaceis, acuminatis, basi obtusis vel rotundatis, nervis utrinque 18 ad 20, perspicuis, utrinque glabris vel costa subtus stellato-pubescentibus; paniculis caulinis, usque ad 31 cm longis; floribus minutis, in ramulis ultimis, dense confertis, glomeratis; fructibus globosis, minute castaneo-stellato-pubescentibus, 2 ad 2.5 cm diametro.

A small tree, the younger parts, inflorescences, and fruits minutely stellate-pubescent with castaneous hairs. Branches terete, the ultimate ones 7 to 10 mm in diameter. Leaves alternate, 43 to 70 cm long; leaflets 11 to 13, subcoriaceous, the lower pairs smaller than the upper ones, oblong-ovate, the others oblong, 15 to 25 cm long, 4.5 to 9 cm wide, the upper surface pale olivaceous-brown, glabrous, slightly shining, the lower surface pale brown to pale reddish brown, nearly glabrous except for the stellate-pubescent midribs and nerves, the apex abruptly acuminate, the acumen acute to obtuse, 5 to 7 mm in length, the base obtuse to rounded; lateral nerves 18 to 20 on each side of the midrib, prominent on the lower surface, becoming faint toward the margins, the reticulations lax, obscure; petiolules stout, 8 to 14 mm long. Panicles from the trunk, densely stellate-pubescent with castaneous hairs, 16 to 31 cm long, the branches few, spreading, the lower ones up to 14 cm long. Immature flowers very densely crowded on the ultimate branchlets, glomerate, about 0.75 mm in diameter, the pedicels up to 0.5 mm long. Calyx densely stellate-pubescent, 0.4 to 0.5 mm long. Petals 5, suborbicular, glabrous, rounded, about 0.3 mm long. Staminal tube glabrous, depressed-globose, truncate, free from the petals, the anthers 5, about 0.2 mm long, included. Fruits globose, rounded, densely and minutely stellate-pubescent with

castaneous hairs, 2 to 2.5 cm in diameter, with a single vertical median ridge, the pedicels stout, up to 1.4 cm long.

MINDANAO, Davao Province, Mayo, *Bur. Sci. 49374* (type), April 24, 1927, along streams in damp forests, altitude about 700 meters; Mati, *49107 Ramos and Edaño*, May 6, 1927, in damp forests along Bitanagan River, at low altitudes.

One of the few species of this large genus with cauline inflorescences, apparently falling in the group with *Aglaia trunciflora* Merrill, which is known from fruiting specimens only. It differs from the above species in its globose, minutely and densely castaneous pubescent fruits. It is further characterized by its very densely crowded flowers.

Genus DYSOXYLUM Blume

DYSOXYLUM OBLONGIFOLIOLUM sp. nov. § Eudysoxylum.

Arbor parva, partibus junioribus et subtus foliis et inflorescentiis molliter puberulis; foliis alternis, 45 ad 75 cm longis, foliolis 14 ad 16, vel in foliis superioribus 8 ad 10, lanceolatis vel oblongo-ellipticis, alternis vel suboppositis, acuminatis ad attenuatis, basi acutis, chartaceis, nitidis, supra glabris, vel costa puberulis, in sicco pallidis, nervis lateralibus utrinque 14 ad 18, subtus perspicuis; inflorescentiis in axillis superioribus, spiciformibus ad depauperato-paniculatis, 14.5 ad 22 cm longis, ramis paucis, usque ad 11 cm longis; floribus 4-meris, 6 ad 7.5 mm longis, breviter pedicellatis; calycibus 4-dentatis, extus puberulis, 1.5 ad 2 mm longis, 4.25 ad 4.5 mm diametro, lobis 0.5 ad 1 mm longis; petalis 4, reflexis, extus puberulis, oblongis, subacutis, 7 ad 8 mm longis, 3 ad 4 mm latis; tubo cylindrico, libero, glabro, crenulato, 6 ad 7 mm longo; antheris 8, inclusis, oblongis, subacutis, 1.25 ad 1.5 mm longis, disco cylindrico, crenulato, 2 mm longo; ovario dense pubescente.

A small tree, the branches subterete, obscurely angled, grayish, glabrous, the branchlets, inflorescences, and the upper surface of the leaflets softly olivaceous-puberulent. Leaves alternate, including the petioles 45 to 75 cm long, the petioles 19 to 30 cm long; leaflets 14 to 16, or in the uppermost leaves 8 to 10, the lower ones alternate, the upper opposite or subopposite, lanceolate to oblong-elliptic, 15 to 30 cm long, 3 to 6.3 cm wide, chartaceous, pale olivaceous when dry, shining, the upper surface glabrous except the puberulent midrib, apex acuminate, base subequilateral to more or less inequilateral, acute; lateral nerves 14 to 18 on each side of the midrib, impressed above,

prominent beneath, becoming faint toward the margins, the reticulations lax, somewhat obscure; petiolules densely puberulent, 5 to 10 mm long. Inflorescences in the upper axils, solitary, spiciform to depauperate-paniculate, 14.5 to 22 cm long, the branches few, up to 11 cm long; flowers 4-merous, shortly pedicellate, 6 to 7.5 mm long, the pedicels puberulent, slender, 1 to 1.25 mm long; calyx shallow, 4-toothed, puberulent outside, 1.5 to 2 mm long, 4.25 to 4.5 mm in diameter, the lobes triangular-ovate, 0.5 to 1 mm long; petals 4, reflexed, densely puberulent outside, oblong, subacute, 7 to 8 mm long, 3 to 4 mm wide; staminal tube cylindric, free, glabrous, crenulate, 6 to 7 mm long; anthers 8, included, oblong, subacute, 1.25 to 1.5 mm long; disk tubular, crenulate, glabrous outside, pubescent inside, about 2 mm long, 2.5 mm in diameter; ovary ovoid, densely pubescent, 4-celled; style densely pubescent, including the globose stigma 4.5 to 5 mm long. Immature fruits densely pubescent, globose, about 7 mm in diameter.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 46836, 46827 Ramos and Edaño*, February, 1926, along streams in damp forests, at low altitudes.

The alliance of this species is manifestly with *Dysoxylum venosum* Merrill, from which it is distinguished by its longer inflorescences and much larger flowers.

EUPHORBIACEÆ

Genus ACTEPHILA Blume

ACTEPHILA MEGISTOPHYLLA sp. nov.

Frutex glaber, circiter 4 m altus; foliis permagnis, petiolatis, spathulato-oblanceolatis, chartaceis, 1.1 ad 1.6 m longis, 21 ad 25 cm latis, margine distanter calloso-dentatis vel crenatis, abrupte acute acuminatis, deorsum longe angustatis, nervis utrinque 38 ad 50, perspicuis; petiolo 2.3 ad 3 cm longo; infructescentiis 7.5 ad 13 cm longis, breviter pedunculatis; fructibus longe (4 ad 8.5 cm) pedicellatis, depresso-globosis, extus sparse pubescentibus, 3 ad 3.5 cm diametro.

A shrub about 4 m high. Leaves very large, spatulate-oblanceolate, chartaceous, 1.1 to 1.6 m long, 21 to 25 cm wide, olivaceous-green above, pale brown beneath when dry, glabrous, densely punctulate on both surfaces, margin distantly glandular-dentate or crenulate, apex abruptly acute acuminate, long,

narrowed below; lateral nerves 38 to 50 on each side of the midrib, prominent, parallel, the reticulations lax; petioles relatively short, thickened, glabrous, 2.3 to 3 cm long. Infructescence racemose, shortly peduncled, 7.5 to 13.5 cm long, the peduncles 1 to 2 cm long, covered with appressed short hairs. Capsules depressed-globose, sparingly pubescent, ultimately glabrous, 3 to 3.5 cm in diameter, very long-pedicelled, the pedicels appressed-pubescent, 4 to 8.5 cm long; persistent sepals 5, pubescent outside, margin sparsely ciliate, oblong to ovate, 4 to 6.5 mm long.

LUZON, Tayabas Province, Casiguran, *Bur. Sci. 45466 Ramos and Edaño*, June 2, 1925, in damp forests along streams, at low altitudes.

This species is strongly characterized by its very large leaves, whence its specific name. It probably belongs in the group with *Actephila excelsa* (Dalzell) Mueller-Arg.

Genus ANTIDESMA Burman

ANTIDESMA ACUMINATISSIMUM sp. nov. § Venosa.

Frutex, partibus junioribus inflorescentiisque exceptis glaber; foliis breviter petiolatis, lanceolatis, membranaceis, 7 ad 11.5 cm longis, 1.7 ad 3 cm latis, utrinque nitidis, supra glabris, subtus ad nervis parce pubescentibus, apice longe tenuiterque caudato-acuminatis, basi acutis, nervis utrinque 7 vel 8; stipulis linearis, pubescentibus, 1.25 ad 2 mm longis, deciduis; infructescentiis racemosis, simplicibus, rarissime depauperato-paniculatis, pubescentibus, 4.5 ad 9 cm longis; bractis ovatis, acutis, pubescentibus, 0.25 ad 0.5 mm longis; fructibus rubris, ellipsoideis, inaequilateralibus, glabris, rugosis, 3.25 ad 3.5 mm longis, 1.75 ad 2 mm diametro, stigmatibus terminalibus, calycibus 4-meris; pedicellis tenuibus, pubescentibus, 1.75 ad 2 mm longis.

A shrub about 2 m high; the branches slender, terete, smooth, the branchlets pubescent. Leaves lanceolate, membranaceous, 7 to 11.5 cm long, 1.7 to 3 cm wide, olivaceous, shining on both surfaces, glabrous above, sparsely pubescent on the nerves beneath, long and slenderly caudate-acuminate, base acute; lateral nerves 7 or 8 on each side of the midrib, slender, the reticulations somewhat obscure; petioles short, slender, 2 to 3 mm long; stipules linear, pubescent, 1.25 to 2 mm long, up to 0.75 mm wide at the base, deciduous. Infructescences simple, or rarely

with one branch, 4.5 to 9 cm long, slender, pale pubescent; bracteoles ovate, acute, pubescent, 0.25 to 0.5 mm long; calyx teeth 4, ovate, recurved. Fruits reddish, ellipsoid, inequilateral, somewhat compressed, glabrous, somewhat rugose when dry, 3.25 to 3.5 mm long, 1.75 to 2 mm in diameter; stigma terminal, arms short, 3 or 4, recurved; the pedicels slender, pubescent, 1.75 to 2 mm long.

LUZON, Tayabas Province, Casiguran, *Bur. Sci. 45189 Ramos and Edaño*, June 9, 1925, in the open and on river flats, altitude about 200 meters.

A species in the group with *Antidesma pentandrum* (Blanco) Merrill. The slender infructescences, the small, ellipsoid, somewhat compressed fruits, the minute ovate bracteoles, the linear, minute, stipules, and the lanceolate, caudate-acuminate leaves are characteristic.

Genus PHYLLANTHUS Linnæus

PHYLLANTHUS RAMOSII sp. nov.

Frutex glaber, dioicus, ramis teretibus, 4.5 ad 5.5 mm diametro, ramulis numerosis, 22 ad 37 cm longis, 2 ad 2.5 mm diametro, tenuibus; foliis ovatis, chartaceis, tenuiter caudato-acuminatis, basi aequilateraliter acutis ad rotundatis, 7 ad 12 cm longis, 3 ad 5.3 cm latis, nervis primariis utrinque 6 vel 7, tenuibus; floribus ♂ axillaribus, fasciculatis, longissime (1.2 ad 2.6 cm) pedicellatis, pedicellis filiformibus; perianthi segmentis 5, rarissime 6, oblongo-ovatis ad lanceolatis, obtusis, circiter 3 mm longis; staminibus 5, 1.5 ad 1.75 mm longis, filamentis liberis, ad 1 mm longis, antheris oblongis ad oblongo-ovatis, longitudinaliter dehiscentibus.

A glabrous diœcious shrub, about 3 m high; the branches terete, glabrous, pale reddish brown to pale brown, 4.5 to 5.5 mm in diameter, bearing numerous, somewhat crowded, slender branchlets, these 22 to 37 cm long, 2 to 2.5 mm in diameter, each subtended by 2 or 3, cuneate, rigid, acutely acuminate stipule-like bracts, 1.5 to 2.5 mm in length. Leaves numerous, brown, chartaceous, ovate, prominently caudate-acuminate, base equilateral, acute to rounded, 7 to 12 cm long, 3 to 5.3 cm wide; lateral nerves 6 or 7 on each side of the midrib, rather prominent, the reticulations rather lax, upper surface black and shining when dry, lower paler, rather dull; petioles glabrous, 4 to 6 mm long; stipules ovate, acute, slightly concave, about 3 mm long, deciduous. Staminate flowers axillary, fascicled, long-pedi-

cellate, their pedicels very slender, 1.2 to 2.4 cm long; perianth segments 5, very rarely 6, glabrous, membranaceous, subequal, oblong-ovate to lanceolate, obtuse, about 3 mm long, 1 to 2 mm wide; stamens 5, 1.5 to 1.75 mm long, their filaments free, slender, up to 1 mm long, the anthers oblong to oblong-ovoid, laterally longitudinally dehiscent; disk glands free, oblong, 0.2 to 0.25 mm long.

LUZON, Isabela Province, Mount Moises, *Bur. Sci. 47336 Ramos and Edaño*, March 4, 1926, along forested streams, altitude about 1,400 meters.

A species remote from any hitherto described from the Philippines. The large, ovate, caudate-acuminate leaves and the long-pedicellate staminate flowers are characteristic.

DAPHNIPHYLLACEÆ

Genus DAPHNIPHYLLUM Blume

DAPHNIPHYLLUM PARVIFOLIUM sp. nov.

Frutex glaber; ramulis subrugosis, teretibus; foliis parvis, oblongo-ellipticis ad oblongo-oblanceolatis, coriaceis, 4 ad 9 cm longis, 1 ad 2 cm latis, supra olivaceis ad pallide brunneis, nitidis, glabris, subtus brunneis, minutissime papillosis, apice obtusis ad late rotundatis, interdum minute apiculatis, base acutis, nervis primariis utrinque 6 ad 9, distinctis; inflorescentiis ♂ axillaribus, pedunculatis, subumbellatis vel corymbosis, 2 ad 4 cm longis, paucifloris; staminibus 5 ad 9, umbellatis, antheris oblongis, erectis, 1 ad 1.5 mm longis, filamentis quam antheris paullo brevioribus; fructibus oblongo-ellipsoideis, 10 ad 12 mm longis, stigmatibus 2, recurvatis, brevissimis, sessilibus; calycibus 0 vel caducis.

A glabrous shrub, 1 to 2 m high, the branches terete, brown, slightly wrinkled, the branchlets smooth, reddish brown. Leaves small, numerous, oblong-elliptic to oblong-oblanceolate, 4 to 9 cm long, 1 to 2 cm wide, olivaceous or pale brown, shining, glabrous above, brown to dark brown and minutely papillose beneath, coriaceous, apex obtuse to broadly rounded, sometimes minutely apiculate, base acute; lateral nerves 6 to 9 on each side of the midrib, distinct on both surfaces; petioles reddish brown to dark brown, 0.7 to 2.5 cm long. Male inflorescences axillary, pedunculate, subumbellate or corymbose, 2 to 4 cm long, few-flowered; calyx obsolete; stamens 5 to 9, umbellate, anthers oblong, erect, often minutely apiculate, 1 to 1.5 mm long, fila-

ments slightly shorter than the anthers. Infructescences axillary, 3 to 6 cm long. Fruits oblong-ellipsoid, black, 10 to 12 mm long, 5 to 6 mm in diameter; pericarp somewhat rugose when dry; stigmas 2, recurved, sessile; calyx none or caducous.

LUZON, Tayabas Province, Mount Alzapan, *Bur. Sci. 45708* (♂), *45725, 45687* (♀) *Ramos and Edaño*, on slopes in the mossy forest, near the summit, altitude about 2,000 meters.

This is the only small-leaved *Daphniphyllum* known. It is allied to *Daphniphyllum obtusifolium* Merrill, but differs in its smaller leaves, which are minutely papillose beneath, and its oblong-ellipsoid fruits.

CELASTRACEÆ

Genus MICROTROPIS Wallich

MICROTROPIS FASCICULATA sp. nov.

Frutex glaber, circiter 3 m altus; ramulis teretibus, rubro-brunneis; foliis oblongo-ellipticis, subcoriaceis, breviter acuminatis, basi acutis, 21 ad 30 cm longis, 6.5 ad 11 cm latis, nervis primariis utrinque 10 ad 12, tenuibus, distinctis; infructescentiis fasciculatis, caulinis, fructibus oblongis, perspicue acuminatis, rubro-brunneis, laevis, 1.8 ad 2.3 cm longis, 0.8 ad 0.95 cm diametro.

A glabrous shrub about 3 m high, the branchlets smooth, terete, reddish brown, 4 to 7 mm in diameter. Leaves subcoriaceous, when dry olivaceous-green on the upper surface, light brown on the lower surface, shining on both surfaces, oblong-elliptic, apex shortly and subacutely acuminate, base somewhat narrowed, acute, 21 to 30 cm long, 6.5 to 11 cm wide, primary lateral nerves 10 to 12 on each side of the midrib, distant, slender, distinct, anastomosing, the reticulations lax, somewhat obscure; petioles 1.4 to 2.3 cm long. Infructescences fascicled, cauline; the fruits not numerous, brown when fresh, reddish brown when dry, oblong, with prominently acuminate apex, smooth to shallowly grooved, 1.8 to 2.3 cm long, 0.8 to 0.95 cm in diameter; the pedicels very short, up to 2 mm long; calyx 4 to 6 mm in diameter, the sepals ovate, rounded, 1 to 1.5 mm in length.

PANAY, Capiz Province, Ilamanay, *Bur. Sci. 46147 Edaño*, October 8, 1925, on forested slopes, at low altitudes.

This species is radically different from the previously described Philippine representatives of the genus in its cauline, fascicled fruits and its oblong-elliptic leaves. Its alliance is probably with *Microtropis wallichiana* Wight, of Ceylon.

SAPINDACEÆ

Genus OTOPHORA Blume

OTOPHORA GRANDIFOLIOLA sp. nov.

Frutex glaber; foliis circiter 65 cm longis, foliolis 6 ad 8, subcoriaceis, oblongo-ellipticis, usque ad 34 cm longis, 10.5 cm latis, nitidis, subacutis, basi cuneatis, nervis primariis utrinque 9 ad 12, perspicuis; stipulis suborbiculari-ovatis, subcoriaceis, inaequilateralibus, usque ad 6 cm longis; inflorescentiis paniculatis, pyramidatis, usque ad 36 cm longis, ramis paucis vel numerosis, inferioribus usque ad 12 cm longis; floribus pedicellatis, 4-meris, sepalis 4 ad 4.5 mm longis; petalis suborbicularis, circiter 3.5 mm longis; fructibus junioribus ellipsoideis, in siccitate rubro-brunneis, circiter 0.8 cm diametro.

A glabrous shrub, 3 to 4 m high. Branches terete, brownish or grayish, lenticellate. Leaves about 65 cm long, the leaflets 6 to 8, subcoriaceous, oblong-elliptic, 26 to 34 cm long, 7 to 10.5 cm wide, or the basal ones sometimes smaller up to 19 cm by 5 cm, subacute, base cuneate, when dry pale or brown above, light brown beneath; primary lateral nerves 9 to 12 on each side of the midrib, prominent, curved, anastomosing, the reticulations prominent on both surfaces; stipules suborbicular-ovate, obtuse, up to 6 cm long, 5 cm wide, similar to the leaves in texture and color, inequilateral; petiolules short, 4 to 8 mm long. Panicles from the upper axils, pyramidal, 23.5 to 36 cm long, the branches few or numerous, spreading, the lower ones up to 12 cm long. Flowers dark reddish brown when dry, the pedicels 5 to 10 mm long, slender. Sepals 4, ovate to suborbicular, obtuse to rounded, 4 to 4.5 mm long, 3 to 4 mm wide, the margins very sparsely minutely denticulate. Petals 4, about 3.5 mm long, 3 mm wide, suborbicular, margins inflexed and ciliate at the base. Stamens 8, 2.75 to 3 mm long; the anthers narrowly oblong, acute, 1.5 to 1.75 mm long, the filaments flattened at the base. Ovary ellipsoid, 2-celled, glabrous; style very short; stigma obsoletely 2-lobed. Fruits (young) ellipsoid, reddish brown when dry, about 0.8 cm in diameter.

MINDANAO, Davao Province, Mati, *Bur. Sci. 49051 Ramos and Edaño*, April 13, 1927, in dry forests at low altitudes.

This species is allied to *Otophora fruticosa* Blume, but is distinguished among other characters by its very large leaflets and stipules.

VITACEÆ

Genus AMPELOCISSUS Planchon

AMPELOCISSUS DOLICHOBOTRYS sp. nov. § **Kalocissus.**

Frutex scandens, glaber, ramis teretibus, ramulis junioribus plus minusve tomentosis; foliis pedatim 5- rariter 3-foliolatis, foliolis membranaceis, oblongis ad ellipticis, 16 ad 24 cm longis, acuminatis, lateralibus basi valde inaequilateralibus, margine distanter repando-dentatis; inflorescentiis elongatis, usque ad 1 m longis, ramis primariis numerosis, distantibus, patulis, 3 ad 6.5 cm longis; floribus 4-meris, partibus junioribus leviter pubescentibus, sessilibus; petalis oblongis, 2.7 ad 3 mm longis, subacutis ad obtusis; fructibus junioribus carnosis, globoso-ovoideis, circiter 1.2 cm longis.

A scandent shrub, the branches terete, glabrous, the branchlets more or less tomentose with rather long deciduous matted hairs which in age become white. Tendrils 30 to 35 cm long, 1.5 to 2 mm in diameter at the base. Leaves pedately 5-foliolate, rarely 3-foliolate; the petioles 7 to 13 cm long; leaflets membranaceous, acuminate, margins distantly sinuate-toothed above the middle, and sometimes below, the upper surface glabrous and shining, the lower tomentose on the midrib and nerves, the central leaflet elliptic to oblong-obovate, base equilateral acute, 16.5 to 24 cm long, 8 to 11 cm wide, the petiolule tomentose, 3 to 3.5 cm long, the lateral leaflets oblong to elliptic or oblong-obovate, the base very inequilateral, one side acute, the other rounded to semicordate, 17 to 25 cm long, 7.5 to 11 cm wide, the petiolule tomentose, 1.3 to 2.5 cm long, lateral nerves distinct, 6 to 8 on each side of the midrib. Inflorescence very long, the flower-bearing part 53 to 94 cm long, the very long peduncles 48 to 60 cm long; the spiciform primary branches 34 to 54, slender, the axis minutely puberulent, the rachis sparsely tomentose. Flowers 4-merous, sessile, scattered, each subtended by a small triangular bracteole; calyx shallow, minutely puberulent on the outside, shortly lobed, 1.5 to 1.75 mm long, 1.75 to 2 mm in diameter, the lobes somewhat rounded; petals oblong, minutely puberulent outside, dark red, purplish brown when dry, subacute to obtuse, 2.75 to 3 mm long, 1.25 to 1.5 mm wide. Stamens about 2.75 mm long; anthers oblong, about 1 mm long. Ovary ovoid, minutely puberulent. Young fruits very fleshy, glabrous, globose-ovoid, about 1.2 cm long, 1.15 cm in diameter, with a single seed.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 47173 Ramos and Edaño,* March 23, 1926, along forested streams in damp forests, altitude about 600 meters.

A species manifestly allied to *Ampelocissus botryostachys* Planchon, differing radically in its very long inflorescences.

AMPELOCISSUS TRICHOCLADA sp. nov. § Kalocissus.

Frutex scandens, ramis ramulisque tomentosis, teretibus; foliis 3-foliolatis, foliolis membranaceis, supra glabris vel glabrescentibus, subtus ad costa nervisque dense tomentosis, plerumque oblongis, 19 ad 28 cm longis, 8 ad 13 cm latis, lateralibus valde inaequilateralibus, acute acuminatis, margine distanter sinuatis; inflorescentiis elongatis, usque ad 74 cm longis, pedunculis usque ad 39 cm longis, ramis primariis numerosis, distantibus, patulis, 2 ad 4 cm longis; floribus 4-meris, glabris, sessilibus.

A scandent shrub, conspicuously tomentose except the flowers and the ultimate branches of the inflorescences; the branches terete, densely covered with long, persistent, wooly, matted, cinnamomous hairs which in age become paler. Tendrils up to 48 cm long. Leaves 3-foliolate, the petioles 9 to 12 cm long; leaflets membranaceous, olivaceous-green, acutely acuminate, the margins distantly sinuate-toothed, the young ones more or less pubescent on both surfaces, the older ones sparsely tomentose to glabrescent above, shining, the lower surface tomentose on the midrib, primary nerves, and margins, pubescent on the reticulations; lateral nerves distinct, 9 to 11 on each side of the midrib, the central leaflet usually oblong-elliptic, equilateral, base cuneate, 26 to 28 cm long, 11 to 12.5 cm wide, the petiole densely tomentose, about 1 cm long, the lateral leaflets oblong-ovate, the base very inequilateral, acute, the inner side narrow, the outer one broad, the basal margins forming nearly a right angle, 19 to 25 cm long, 8 to 13 cm wide, the petiolules densely tomentose, 0.3 to 0.5 cm long. Inflorescence long, pendant, the flower-bearing part about 35 cm long, the peduncles 31 to 39 cm long, the axis tomentose; the spiciform primary branches about 45, slender, distant, glabrous, 2 to 4 cm long. Flowers 4-merous, purple, glabrous, sessile, each subtended by a small triangular bracteole. Calyx shortly 4-lobed, about 1.75 mm long, 1.75 mm in diameter, the lobes about 0.5 mm long, somewhat rounded at the apex. Petals oblong, acute to obtuse, about 2.5 mm long. Stamens 4, anthers oblong, about 1.25 mm long, the filaments subulate, about 0.75 mm long. Ovary oblong-ovoid, glabrous.

MINDANAO, Davao Province, Pagdaugan, *Bur. Sci. 49627 Ramos and Edaño,* June 12, 1927, on forested slopes, altitude about 700 meters.

A species doubtless allied to the proceeding one, differing essentially in its densely tomentose branches and leaflets, shorter inflorescences, the lateral leaflets acute at the base, and its glabrous flowers.

Genus **LEEA** Royen

LEEA PYCNANTHA sp. nov.

Frutex circiter 1 m altus, glaber; ramis canaliculatis; foliis simplicibus, obovatis, chartaceis ad subcoriaceis, 24 ad 34 cm longis, 12 ad 20 cm latis, brevissime acuminatis, deorsum angustatis, basi abrupte obtusis, margine crenato-denticulatis, nervis lateralibus utrinque 11 ad 14, subtus valde perspicuis; inflorescentiis in axillis superioribus, brevibus, 2.5 ad 4 cm longis; floribus numerosis, confertis, 4-meris, luteis, 5 ad 6 mm longis.

A shrub about 1 m high, glabrous; branches and branchlets deeply furrowed, dark-colored when dry, the ultimate branchlets 6 to 8 mm in diameter. Leaves simple, obovate, chartaceous to subcoriaceous, 24 to 34 cm long, 12 to 20 cm wide, apex very shortly acuminate, base subequally narrowed, abruptly obtuse, margins prominently crenate-denticulate, the teeth minute, often glandular, the upper surface dark brown when dry, the lower much paler and somewhat shining; lateral nerves 11 to 14 on each side of the midrib, very prominent, somewhat ascending, anastomosing close to the margins, the reticulations very distinct; petioles broadly vaginate, 2.5 to 3.5 cm long. Inflorescences in the upper axils, short, 2.5 to 4 cm long. Flowers numerous, crowded, yellow, 5 to 6 mm long; calyx cup-shaped, 3.25 to 3.75 mm long, 3.75 to 4 mm in diameter, the lobes 4, about one-third as long as the tube, triangular, subacute to acute; corolla tube 2 to 2.25 mm long, the lobes 4, fleshy, reflexed, oblong, subacute, 3 to 3.25 mm long; staminal tube united with the corolla, exerted, about 2.5 mm long; anthers 4, about 2 mm long; ovary ovoid; style about 1.75 mm long.

LUZON, Nueva Vizcaya Province, Mount Alzapan, *Bur. Sci. 45743 Ramos and Edaño,* May 24, 1925, on forested slopes, altitude about 1,700 meters.

A species apparently different from all hitherto known Philippine forms with simple leaves. It is distinguished by its large obovate leaves, and short, very much crowded, inflorescences.

TILIACEÆ

A recent partial treatment of this group involves certain changes in nomenclature for some Philippine species. Burret's recent study [3] adds two genera, *Pentace* and *Althoffia,* to the Philippine list, or three, if we follow him in the segregation of *Microcos* Linnæus from *Grewia* Linnæus. It is of interest to note that of the three additional genera mentioned above *Pentace* is strictly western Malaysian, while *Althoffia* is strictly eastern Malaysian in the distribution of the other known species.

Genus BERRIA Roxburgh

BERRIA CORDIFOLIA (Willdenow) Burret.

Berrya cordifolia (Willdenow) BURRET in Notizbl. Bot. Gart. Berlin **9** (1926) 606.

This name, based on *Espera cordifolia* Willdenow, is earlier than, and thus replaces, *Berria ammonilla* Roxburgh. Burret prefers the spelling *Berrya* to Roxburgh's original *Berria.*

Genus BROWNLOWIA Roxburgh

BROWNLOWIA BECCARI (Masters) Pierre.

Brownlowia beccari (Masters) Pierre; BURRET in Notizbl. Bot. Gart. Berlin **9** (1926) 1164.

Burret refers the Philippine material, originally identified by Merrill with *Brownlowia lanceolata* Bentham, to this Bornean species, its range being now Borneo and the Philippines. *Brownlowia lanceolata* Bentham and *B. beccari* Pierre apparently represent very closely allied species, and complete material may indicate that the latter should be reduced to the former.

Genus PENTACE Hasskarl

PENTACE SUBINTEGRA (Merrill) Burret.

Pentace subintegra (Merrill) BURRET in Notizbl. Bot. Gart. Berlin **9** (1926) 620.

Columbia subintegra MERRILL in Philip. Journ. Sci. **10** (1915) Bot. 323.

This species, originally described from fruiting material, proves to belong in *Pentace;* the genus, otherwise confined to western Malaysia, is new to the Philippines.

[3] Burret, M., Beiträge zur Kenntnis der Tiliaceen, Notizbl. Bot. Gart. Berlin **9** (1926) 592 880, II op. cit. (1927) 1161–1174.

Genus GREWIA Linnæus

Other than the segregation of *Microcos* Linnæus, as a valid genus (see below), the following proposed changes affect Philippine species:

GREWIA ROLFEI Merrill var. RIZALENSIS (Merrill) Burret.

Grewia rolfei Merrill var. *rizalensis* (Merrill) BURRET in Notizbl. Bot. Gart. Berlin 9 (1926) 647.

Grewia rizalensis Merrill is reduced as a variety of *G. rolfei* Merrill.

GREWIA KOORDERSIANA Burret.

Grewia koordersiana BURRET in Notizbl. Bot. Gart. Berlin 9 (1926) 662.

Burret suspects that the Luzon material referred by Merrill to *Grewia asiatica* Linnæus belongs to this Javan species. The discontinuous distribution would seem to militate against the correctness of this view.

GREWIA PARVA Merrill.

Grewia parva Merrill; BURRET in Notizbl. Bot. Gart. Berlin 9 (1926) 769.

Burret believes that the Philippine form is specifically distinct from the Indo-China *Grewia bilamellata* Gagnepain to which Merrill reduced it.

GREWIA SETACEOIDES Burret.

Grewia setaceoides BURRET in Notizbl. Bot. Gart. Berlin 9 (1926) 679.

LUZON, Bulacan Province, Norzagaray, *Bur. Sci. 13018 Ramos.*

This is described as a new species, based on the above collection, and is allied to *Grewia setacea* Merrill.

GREWIA ACUMINATA Jussieu.

Grewia acuminata Jussieu; BURRET in Notizbl. Bot. Gart. Berlin 9 (1926) 699.

Burret retains this as a strictly Javan species closely related to the more widely distributed *Grewia umbellata* Roxburgh and were he correct then Roxburgh's specific name would replace Jussieu's for the Philippine form. Knowing that Jussieu's type was preserved in the Paris Museum we communicated with Dr. F. Gagnepain, asking him to compare the material. On the basis of his own intensive knowledge of the Indo-Malaysian species of *Grewia*, a critical examination of Jussieu's type, and the abundant material from various parts of Malaysia and the Philip-

pines, he wrote under date of February 16, 1928 that he considered that Dr. Hochreutiner was correct in his interpretation of Jussieu's species; and that it was practically impossible to distinguish between *Gerwia acuminata* Jussieu and *G. umbellata* Roxburgh. Hochreutiner's No. 37 is true *Grewia acuminata* Jussieu, and Philippine specimens are referable to the same species. Therefore, we retain Jussieu's name for the Philippine form.

Genus MICROCOS Linnæus

This genus is retained as a valid one distinct from *Grewia* to which all previous modern authors have referred it. Four Philippine species are known.

MICROCOS PYRIFORMIS (Elmer) Burret.

Microcos pyriformis (Elmer) BURRET in Notizbl. Bot. Gart. Berlin **9** (1926) 772.

Grewia pyriformis ELMER Leafl. Philip. Bot. **8** (1915) 2841.

MINDANAO, *Elmer 13996*. Endemic.

MICROCOS STYLOCARPA (Warburg) Burret.

Microcos stylocarpa (Warburg) BURRET in Notizbl. Bot. Gart. Berlin **9** (1926) 780.

Grewia stylocarpa WARBURG in Perkins Frag. Fl. Philip. (1904) 104.

Widely distributed in the Philippines; a variety *longipetiolata* Burret, in Borneo.

MICROCOS PHILIPPINENSIS (Perkins) Burret.

Microcos philippinensis (Perkins) BURRET in Notizbl. Bot. Gart. Berlin **9** (1926) 781.

Grewia philippinensis PERKINS Frag. Fl. Philip. (1904) 103.

Widely distributed in Luzon. Endemic.

MICROCOS INFLEXA (Merrill) Burret.

Microcos inflexa (Merrill) BURRET in Notizbl. Bot. Gart. Berlin **9** (1926) 795.

Grewia inflexa MERRILL in Philip. Journ. Sci. **11** (1916) Bot. 194.

SAMAR. Endemic.

Genus COLUMBIA Persoon

Burret prefers the older original name *Colona* as published by Cavanilles, and considers all species under the former generic name. New names of Philippine species are *Colona megacarpa* (Merrill) Burret, page 800; *C. mollis* (Warburg) Burret, page 802; *C. subaequalis* (Planchon) Burret, page 802, with descrip-

tion; *C. lanceolata* (Warburg) Burret, page 804; *C. hirsuta* (Warburg) Burret, page 804 (to this are reduced *Columbia inaequidentata* Warburg and *C. macgregorii* Merrill); *Colona jagori* (Warburg) Burret, page 813; and *C. philippinensis* (Vidal) Burret, page 813.

Genus ALTHOFFIA K. Schumann

ALTHOFFIA LANIGERA (Blanco) Burret.

Althoffia lanigera (Blanco) BURRET in Notizbl. Bot. Gart. Berlin 9 (1926) 858.

This is based on *Eroteum lanigerum* Blanco (1837), which in 1918 was transferred to *Trichosporum* as *T. lanigerum* Merrill, replacing *Trichosporum trivalve* Merrill. The genus is new to the Philippines and in distribution is Philippine-eastern Malaysia as contrasted to *Pentace* mentioned above, which is Philippine-western Malaysia. Five species are now known, one in the Philippines, three in New Guinea, and one extending from the Moluccas to the Bismarck Archipelago, New Guinea, and northeastern Australia.

GUTTIFERÆ

Genus CALOPHYLLUM Linnæus

CALOPHYLLUM MEGISTANTHUM sp. nov. § Inophyllum.

Arbor 6 ad 10 m alta; ramis teretibus glabris, ramulis junioribus subangulatis vel sulcatis cum inflorescentiisque dense ferrugineo-pubescentibus; foliis coriaceis, oblongis ad oblongo-ellipticis, 21 ad 30 cm longis, 7 ad 8.2 cm latis, supra in siccitate pallidis, nitidis, utrinque glabris, brevissime obtuse acumnatis, basi acutis; petiolo 2.5 ad 4 cm longo; inflorescentiis terminalibus et in axillis superioribus, racemosis vel paniculatis, 17 ad 30 cm longis, paucifloris; pedunculis 7.5 ad 12.5 cm longis; floribus permagnis, usque ad 5 cm diametro, albidis; pedicellis 2.3 ad 3.8 cm longis; sepalis 6, binis exterioribus late ovatis, rotundatis, circiter 1 cm longis, interioribus majoribus; petalis 2 ad 2.5 cm longis.

A tree, 6 to 10 m high; the branches stout, terete, glabrous, 5 to 8 mm in diameter, the branchlets somewhat angled or sulcate, reddish brown, ferruginous-pubescent. Leaves coriaceus, oblong to oblong-elliptic, 21 to 30 cm long, 7 to 8.2 cm wide, shortly and obtusely acuminate, base acute, upper surface shining and pale when dry, the lower surface brownish yellow, glabrous on both surfaces; lateral nerves very numerous, very slender, parallel; petioles 2.5 to 4 cm long, glabrous or sparsely pubescent. Inflorescences terminal and in the upper axils, race-

mose or paniculate, the older parts sparsely ferruginous-pubescent, the younger parts densely so, 17 to 30 cm long, including the peduncles, few-flowered; the peduncles 7.5 to 12.5 cm long. Flowers white, large, up to 5 cm in diameter, the lower pedicels up to 3.8 cm long, the upper ones shorter, the uppermost 2.3 cm in length. Sepals 6, the two outer ones coriaceous, pubescent, broadly ovate, about 1 cm long, the inner ones subglabrous to pubescent, suborbicular to oblong-obovate, 1.6 to 2.1 cm long. Petals white, oblong-obovate, rounded, very slightly pubescent, 2 to 2.5 cm long, 1.5 to 1.6 cm wide. Stamens very numerous, yellow. Ovary glabrous, ovoid-globose.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 47137 Ramos and Edaño*, March 15, 1926, in damp forests, altitude about 300 meters.

This species is perhaps allied to *Calophyllum ferrugineum* Merrill, but is strikingly different from that. It is well characterized by its oblong to oblong-elliptic, large, glabrous leaves, with very numerous and very slender nerves; by its unusually large, 6-merous flowers, and by its elongated, few-flowered racemose and paniculate inflorescences.

FLACOURTIACEÆ

Genus CASEARIA Jacquin

CASEARIA PILOSISSIMA sp. nov.

Frutex, ramulis foliisque valde pubescentibus; foliis chartaceis ad subcoriaceis, oblongis, utrinque dense pilosis, usque ad 23 cm longis, 9.5 cm latis, breviter obtuse acuminatis, basi cordatis, inaequilateralibus, margine crenatis, nervis utrinque 7 ad 9, perspicuis; floribus axillaribus, fasciculatis, 5-meris, tenuiter (5 mm) pedicellatis; staminibus aequalibus, filamentis circiter 1.5 mm longis, antheris 0.6 mm longis; fructibus pilosis, ovoideis ad ellipsoideo-ovoideis, circiter 2 cm longis, in siccitate obscure 6-sulcatis, pedicellis usque ad 9 mm longis.

A shrub, very conspicuously pubescent, the branches and branchlets terete, densely pilose. Leaves oblong, chartaceous to subcoriaceous, 15 to 23 cm long, 5.5 to 9.5 cm wide, shortly and obtusely acuminate, the acumen 8 to 11 mm long, the base inequilateral, broad, somewhat cordate, the margins crenate, both surfaces covered with soft yellowish hairs, very densely pubescent beneath; lateral nerves 7 to 9 on each side of the midrib, prominent on both surfaces, somewhat evanescent toward the margins, curved, anastomosing; petioles densely pilose, 5 to

10 mm long. Flowers 5-merous, axillary, fascicled, their pedicels slender, about 5 mm long, densely pubescent. Sepals ovate, acute, densely pubescent outside, glabrous inside, coriaceous, 2.75 to 3 mm long, 1.5 to 1.75 mm wide. Stamens equal; anthers oblong-ovoid, acute, about 0.6 mm long; filaments very slender, pubescent, about 1.5 mm long. Staminodes pubescent, about 1.25 mm long. Ovary ovoid, densely pubescent, narrowed to the short style, stigma capitate. Fruit yellow when fresh, dark brown when dry, pilose, ovoid to ellipsoid-ovoid, mature fruits about 2 cm long, 1.5 cm in diameter, obscurely 6-sulcate when dry. Seeds about 12 in each fruit, smooth, glabrous, light reddish brown, inequilateral, ovoid, acute, 5 to 6 mm long, their pedicels 7 to 9 mm long.

MINDANAO, Davao Province, Galintan, *Bur. Sci. 48874 Ramos and Edaño,* June 5, 1927, on dry forested slopes, altitude about 200 meters.

A species manifestly allied to *Casearia velutina* Blume and *Casearia grewiifolia* Ventenat, differing in its larger, pubescent fruits and its more-conspicuous and denser indumentum.

BEGONIACEÆ

Genus BEGONIA Linnæus

BEGONIA CASIGURANENSIS sp. nov. § Petermannia.

Herba erecta, pauciramosa, 30 ad 50 cm alta; caulis ramisque pubescentibus, perspicue sulcatis; foliis membranaceis, inaequilateraliter oblongo-obovatis, 7.5 ad 13 cm longis, 4.5 ad 8 cm latis, acutis vel rotundatis, basi oblique obscure subcordatis, margine irregulariter dentatis, subpalmatinerviis, supra glabris, subtus pubescentibus; inflorescentiis ♂ racemosis, terminalibus vel in axillis superioribus, 9.5 ad 20 cm longis; floribus ♂ numerosis, dispersis, perspicue bibracteolatis, segmentis 6.25 ad 7 mm longis, 5.5 ad 6.25 mm latis; staminibus 15–21; floribus ♀ solitariis, rariter binis ad basi inflorescentiis ♂; sepalis 2, 1 ad 1.3 cm longis; capsulis obovatis, rotundatis ad truncatis, basi acutis, 1.7 ad 2.5 cm longis, 1.5 ad 2 cm latis, subaequaliter 3-alatis.

An erect somewhat branched herb, 30 to 50 cm high, the stems up to 1 cm in diameter, prominently sulcate when dry, pubescent with short, appressed, reddish brown hairs. Leaves membranaceous, somewhat inequilateral oblong-obovate to obovate, 7.5 to 13 cm long, 4.5 to 8 cm wide, acute to rounded, base obliquely subcordate, the narrower side acute to narrowly

rounded, the wider rounded and 0.5 to 2.5 cm wide, margins irregularly dentate, sometimes with acute lobes, these lobes never more than 1 cm deep, the upper suface glabrous, somewhat shining, the lower much paler, clothed with short dense reddish brown hairs, particularly on the nerves and reticulations, and the whole surface covered with numerous small whitish dots; nerves 8 to 10, subpalmately arranged, mostly forked, reddish brown, prominent, much darker than the other parts of the lower surface, the reticulations somewhat distinct; petioles pubescent, 0.7 to 1.5 cm long, the lower ones usually longer, up to 3 cm long; stipules oblong, membranaceous, abruptly apiculate-acuminate, reddish brown, pubescent, 1.5 to 2 cm long. Inflorescences in the upper axils or terminal, unbranched, 9.5 to 20 cm long, bearing at the base of the peduncle or at the lowest node of the rachis one or two pistillate flowers or fruits, and above these the racemosely arranged, conspicuously bracteolate staminate flowers, the rachis pubescent; staminate flowers white, each subtended by a pair of conspicous bracteoles, these up to 1.5 cm long, 1.1 cm wide, becoming smaller toward the apex of the inflorescence; pedicels pubescent, up to 1 cm long, slender; sepals 2, oblong-ovate to suborbicular, 7-nerved, 6.25 to 7 mm long, 5.5 to 6.25 mm wide; petals 0; stamens 15 to 21; anthers oblong to oblong-obovoid, 1 to 1.5 mm long, filaments slender, as long as the anthers. Pistillate flowers one or two at the base of the staminate inflorescence; sepals 2, oblong-ovate, 1 to 1.3 cm long, 0.8 to 0.9 cm wide, 7-nerved. Capsules obovate in outline, rounded to truncate, base acute, including the wings 1.7 to 2.5 cm long, 1.5 to 2.1 cm wide, glabrous, subequally 3-winged, the wings in their upper portions 7.5 to 11 mm wide, pedicels 0.8 to 1.2 cm long, slender.

LUZON, Tayabas Province, Casiguran (Cabulig River), *Bur. Sci. 45277 Ramos and Edaño* (type), *45399*, May 28, 1925, along streams and in the open places at low altitudes.

In general the leaves somewhat resemble those of *Begonia robinsonii* Merrill, and perhaps this species is allied to the latter. It differs, however, in its elongated, racemose, simple, staminate inflorescences, the latter, together with the prominently bracteolate flowers being the most striking characters of the species.

BEGONIA ISABELENSIS sp. nov. § Diploclinium.

Foliis longe petiolatis, membranaceis, 10 ad 14.5 cm longis, 6 ad 10.5 cm latis, late oblique ovatis, acute acuminatis, base inaequilateraliter subcordatis, margine breviter paucilobatis, ir-

regulariter denticulatis, dense ciliatis, supra glabris, subtus ad nervis reticulisque villosis, palmatinerviis; petiolo 12.5 ad 25 cm longo; inflorescentiis longe pedunculatis, paucifloris, pedunculis usque ad 44 cm longis; pedicellis ♂ tenuibus; sepalis quam petalis majoribus, rotundato-ovatis ad rotundatis, 12 ad 13.5 mm longis; staminibus circiter 60, liberis; capsulis aliis inclusis in ambitu obovatis, apice truncatis, basi rotundatis, 1.7 ad 2 cm longis, 2.5 ad 3.5 cm latis, valde inaequaliter 3-alatis, alis majoribus usque ad 2.3 cm latis, minoribus vix 1 ad 2 mm latis, angulis superioribus subacutis ad obtusis.

An herb from prostrate rhizomes, these 0.4 to 0.7 cm in diameter. Leaves long-petioled, 10 to 14.5 cm long, 6 to 10.5 cm wide, obliquely broadly ovate, acutely acuminate, base inequilateral, subcordate, rarely obtuse, membranaceous, pale green to olivaceous, glabrous above, sparsely pubescent with light reddish brown hairs beneath, particularly on the nerves and the reticulations, margins with few short angular lobes, the primary ones not more than three, these acute, never more than 1.8 cm deep, margin irregularly denticulate and densely ciliate, base palmately 8-nerved, rarely 5-nerved, the reticulations prominent; petioles long-ciliate when young, becoming glabrous in age, light straw-colored, 12.5 to 25 cm long; stipules light reddish brown, slightly pubescent, oblong-ovate, acuminate, apiculate, 1.7 to 2.5 cm long, 1 to 1.5 cm wide. Inflorescence long-peduncled, dichotomously branched, the primary branches 3.5 to 4.5 cm long, few-flowered, the peduncles glabrous, 32 to 44 cm long, rather stout. Staminate flowers pink and white, their pedicels up to 7 mm long; sepals 2, rounded-ovate to rounded, base subcordate, 12 to 13.5 mm long, 11 to 13 mm wide; petals 2, oblong-ovate to rounded-ovate or rounded, 6 to 7 mm long, 5 to 6 mm wide. Stamens about 60, free; anthers narrowly oblong-obovoid, 1 to 1.5 mm long, equaling or shorter than the filaments. Pistillate flowers as large as the staminate ones. Capsules few, in outline, including the wings, obovate, truncate, base rounded, 1.7 to 2 cm long, 2.5 to 3.5 cm wide, very unequally 3-winged, the wings reticulate, the largest one up to 2.3 cm wide at the top, much longer than the capsule proper and broadly rounded at the base, the next larger one up to 10 mm wide at the top and the smallest one scarcely more than a keel along one face of the capsule, 1 to 2 mm wide at most. Pedicels slender, 3 to 3.5 cm long, angles of the wings subacute to obtuse.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 47207 Ramos and Edaño,* March 14, 1926, on rocks along forested streams, altitude about 400 meters.

A species manifestly allied to *Begonia luzonensis* Warburg, different in its much longer, glabrous peduncles, longer petioles, and larger capsules.

MYRTACEÆ

Genus EUGENIA Micheli

EUGENIA TAYABENSIS sp. nov. § Syzygium.

Frutex glaber; ramulis tenuibus, junioribus 4-angulatis; foliis parvis, coriaceis, 13 ad 25 mm longis, oblongo-obovatis ad elliptico-obovatis vel obovatis, obtusis ad rotundatis, basi acutis, margine revolutis, subtus disperse conspicue atro-punctatis, nervis obscuris ad obsoletis; inflorescentiis terminalibus, brevibus; floribus 4-meris, parvis, calycis tubo 1.5 ad 1.75 mm longo, breviter dentato; petalis rotundatis, 1 ad 1.25 mm longis; staminibus circiter 44, usque ad 2 mm longis.

A glabrous shrub, the trunk about 10 cm in diameter; branches terete, gray, 4 to 6 mm in diameter, the ultimate branchlets slender, about 1 mm in diameter, 4-angled, the angles sometimes narrowly winged, reddish brown to dark brown. Leaves small, numerous, coriaceous, 13 to 25 mm long, 5 to 15 mm wide, oblong-obovate to elliptic-obovate or obovate, obtuse to rounded, base acute, shining above, the lower surface paler and with scattered conspicuous dark-colored glands, margin revolute; lateral nerves obscure to obsolete; petioles slender, 2 to 3 mm long. Cymes terminal, short, including the flowers and peduncles 1.5 to 3.2 cm long, dichotomous or trichotomous, the peduncles slender, 4 to 8.5 mm long; bracts deciduous. Flowers small, 4-merous, white, mostly in threes or in fives, somewhat crowded, about 2.5 mm long; pedicels 3 to 4.75 mm long; bracteoles narrow, up to 1 mm in length; calyx tube turbinate, 1.5 to 1.75 mm long, 2 to 2.5 mm in diameter, the lobes 4, ovate, 0.5 to 1 mm long; petals 4, orbicular, rounded, 1 to 1.25 mm long. Stamens about 44, up to 2 mm long, inflexed.

LUZON, Tayabas Province, Mount Alzapan, *Bur. Sci. 45691 Ramos and Edaño,* June 7, 1925, in the mossy forest, altitude about 2,000 meters.

A species resembling and closely allied to *Eugenia acrophila* C. B. Robinson, differing in its rounded, very obscurely nerved leaves and smaller flowers.

Genus TRISTANIA R. Brown

TRISTANIA MICROPHYLLA sp. nov.

Arbuscula, ramis glabris, teretibus, ramulis junioribus angulatis, parce pubescentibus; foliis numerosis, parvis, coriaceis, 15 ad 31 mm longis, 3.5 ad 10 mm latis, anguste oblongo-lanceolatis ad oblongo-ellipticis, apice attenuatis ad obscure acute acuminatis, basi acutis, margine revolutis, junioribus utrinque pubescentibus, vetustioribus nitidis, utrinque glabris, nervis obscuris ad obsoletis; cymis in axillis superioribus, usque ad 1.6 cm longis, pubescentibus; floribus parvis; calycis tubo turbinato, 5-dentato; petalis orbicularibus, rotundatis, 2 ad 2.25 mm longis; staminibus circiter 18, vix in phalangibus dispositis; capsulis 2.5 ad 3.5 mm longis, pubescentibus.

A small tree about 3 m high, the branches terete, glabrous, light brown, rugose, 5 to 6 mm in diameter, the branchlets glabrous, terete, the ultimate ones 4-angled, the angles obscurely and narrowly winged, appressed-pubescent. Leaves small, numerous, crowded, coriaceous, narrowly oblong-lanceolate to oblong-elliptic, apex attenuate to obscurely and acutely acuminate, base acute, margin revolute, 15 to 31 mm long, 3.5 to 10 mm wide, dark brown, glabrous and shining above, glabrous beneath, the younger ones pubescent on both surfaces; lateral nerves very slender, closely arranged, obscure to obsolete, in cases where a count is possible 20 to 24 on each side of the midrib; petioles 1 to 2.5 mm long. Inflorescences in the upper axils, cymose, including the flowers and peduncles 10 to 16 mm long, densely ferruginous pubescent with appressed hairs, the peduncles slender, 4 to 9.5 mm long; bracts narrowly elliptic, 3.5 to 6 mm long, deciduous. Flowers small, yellow, mostly in threes, 3 to 4 mm long, their pedicels 2 to 3 mm long; bracteoles minute, ovate-lanceolate, acute, 1 to 1.25 mm in length. Calyx tube turbinate, 1 to 1.5 mm long, about 3 mm in diameter, the lobes 5, ovate, subacute to obtuse, 1 to 1.5 mm long. Petals orbicular, rounded, somewhat narrowed at the base, glabrous, 2 to 2.25 mm long, 2 to 2.5 mm wide. Stamens about 18, arranged in one series, although indications of an irregular grouping are evident, 1.75 to 3 mm long. Ovary 3-celled, globose-obovoid, pubescent; style subulate, about 3 mm long, glabrous. Capsules small, dark brown, the valves oblong-ovate, rounded, 2.5 to 3.5 mm long, pubescent with stiff, short hairs.

LUZON, Nueva Vizcaya Province, Mount Alzapan, *Bur. Sci. 45613 Ramos and Edaño*, May 21, 1925, on slopes in the mossy forest, altitude about 1,700 meters.

This species differs from typical *Tristania* in that the stamens are arranged in a single series, although there are indications of an irregular grouping; they are not arranged in definite phalanges, and the filaments are free. It does not appear to belong to any described section of the genus, yet we are confident that it is correctly placed in *Tristania*, although somewhat anomalous in the arrangement of its stamens. It is further characterized by its numerous, unusually small, elliptic leaves and its short, pubescent inflorescences.

MELASTOMATACEÆ

Genus EISOCREOCHITON novum

Flores 4-meri. Calycis tubus urceolatus vel ovoideus, decidue stellati; limbus subdilatatus, minute 4-lobatus. Petala 4, oblonga, obtusa, glaberrima. Stamina 4, aequalia, filamentis tenuibus, antherae subulatae, incurvae, minute 1-porosae, connectivo infra loculos non producto, incrassato, transverse subcordato, antice breviter biappendiculato, postice 1-appendiculato. Ovarium 4-loculare, vertice puberulum; stylus filiformis; stigmate punctiformi. Fructibus ignotis. Frutex scandens, caule elongato, teretiusculo, dense plumoso-stellato. Folia opposita, petiolata, subcoriacea, ovata, parva, integerrima, 5-nervia. Flores parvi vel mediocri, pauci, pedicellati, perspicue bibracteati, in paniculas racemiformes axillares dispositi.

EISOCREOCHITON BRACTEATA sp. nov. Plate 4.

Frutex scandens, partibus junioribus perspicue stellatim plumoso-tomentosus, indumento ferrugineo, ramulis teretibus, gracilis, 1 ad 1.5 mm diametro; foliis oppositis, ovatis, distincte acuminatis, utrinque viridibus, basi acutis, 3.2 ad 5.5 cm longis, 1.6 ad 3.5 cm latis, supra glabris vel junioribus dense decidue ferrugineo-tomentosis, subtus plumoso-stellatis, vetustioribus glabrescentibus, 5-nerviis, nervis perspicuis, nervulis transversalibus tenuibus; petiolo 1.2 ad 2 cm longo, decidue stellatim plumoso-tomentoso; inflorescentiis paucifloris, pedunculatis, bracteatis, bracteis bracteolisque perspicuis, membranaceis, oblongo-ovatis ad late ovatis, 8 ad 11 mm longis, 4 ad 8 mm latis, bracteolis floribus involucrantibus; calycis tubo 3 ad 4 mm longo; petalis 6.5 ad 7.25 mm longis; antheris circiter 4 mm longis, connectivo basi incrassato, haud producto, transverse subcordato.

A scandent shrub with very hard wood, the branchlets 1 to 1.5 mm in diameter, slender, terete, densely covered with ferruginous plumose-stellate, ultimately deciduous indumentum. Leaves

ovate, distinctly acuminate, base acute, chartaceous to subcoriaceous, 3.2 to 5.5 cm long, 1.6 to 3.5 cm wide, both surfaces green, the lower slightly paler, the upper surface glabrous, the lower surface more or less covered with ferruginous plumose-stellate hairs, which are deciduous in age, the very young leaves densely pubescent on both surfaces, 5-nerved, the longitudinal nerves prominent, the inner pair much more conspicuous than the marginal ones, reaching the apex, the transverse nervules and reticulations slender, distinct; petioles 1.2 to 2 cm long, slender, plumose-stellate-pubescent, the older ones glabrous. Inflorescence racemiform, few-flowered, pedunculate, axillary, conspicuously ferruginous plumose-stellate-pubescent, 4 to 5 cm long, the peduncles 1.6 to 2 cm in length. Flowers 4-merous, pedicellate, bibracteolate, the branches bearing solitary flowers bibracteate, the pedicels (branches) about 10 mm long; bracts and bracteoles membranaceous, pale green, oblong-ovate to broadly ovate, 8 to 11 mm long, 4 to 8 mm wide, more or less concave, the bracteoles more or less inclosing the flowers; calyx tube 3 to 4 mm long, minutely lobed, when young densely stellate-pubescent, soon becoming glabrous; petals 4, white, oblong, obtuse, entire, 6.5 to 7.25 mm long, about 4 mm wide; stamens 4, equal, their filaments slender, about 4 mm long; anthers subulate, curved, attenuate, dehiscing by an apical pore, about 4 mm long, the connective thickened, not produced, transversely cordate, anteriorly shortly 2-appendiculate, posteriorly shortly 1-appendiculate; ovary 4-celled, adhered to the calyx, the apex puberulent; style slender, 8.5 to 8.75 mm long; stigma punctiform.

LUZON, Nueva Vizcaya Province, Mount Alzapan, *Bur. Sci. 45610 Ramos and Edaño*, May 24, 1925, climbing on trees on forested slopes, altitude about 1,700 meters.

Although in vegetative and inflorescence characters this species closely approximates *Creochiton*, its floral characters are totally different. It seems clearly to fall in the tribe Oxysporeæ, near *Blastus*, although radically different from this genus in its prominently bracteate and bracteolate flowers and its thickened but not produced, transversely cordate, anteriorly biappendiculate and posteriorly 1-appendiculate connectives. The collector notes that the wood is unusually hard and tough.

Genus MEDINILLA Gaudichaud

MEDINILLA MULTIALATA sp. nov. § Eumedinilla.

Frutex scandens, epiphyticus, glaber, ramis anguste 8-alatis; foliis verticillatis, brevipetiolatis, late ellipticis ad obovatis,

usque ad 23 cm longis, 12 cm latis, 7-plinerviis, apice abrupte submucronato-acuminatis, basi decurrento-acuminatis; infructescentiis axillaribus, brevibus, pedunculatis, paucifloris; fructibus 5-locellatis, glabris, paucis, obovoideis, truncatis, 1.5 ad 2 cm longis, 1.5 ad 1.75 cm diametro.

A scandent, epiphytic, glabrous shrub, the branches narrowly 8-winged, 8-sulcate, 7 to 8 mm in diameter. Leaves in whorls of 4 at each node, broadly elliptic to obovate, 14 to 23 cm long, 7.5 to 12 cm wide, membranaceous when dry, abruptly submucronate-acuminate, the slender acumen 4 to 8 mm long, the base decurrent-acuminate, 7-plinerved, the upper four lateral nerves prominent, reaching the apex, the external ones slender, somewhat obscure; petioles 5 to 10 mm long. Infructescence peduncled, up to 7.5 cm long, in the axils of fallen leaves, subcymose, the peduncles 1.5 to 5 cm long. Fruits few, dark red, glabrous, 5-celled, pulpy, subumbellate on the few primary branches, obovoid, truncate, 1.5 to 2 cm long, 1.5 to 1.75 cm in diameter, their pedicels 1 to 1.3 cm long.

MINDANAO, Davao Province, Mount Mayo, *Bur. Sci. 49447 Ramos and Edaño*, May 16, 1927, on damp forested slopes, altitude about 1,000 meters.

A species belonging in the group with *Medinilla pterocaula* Blume and *Medinilla crispata* Blume, differing strikingly in its much larger, broadly elliptic to obovate, mucronate, 7-plinerved leaves.

MEDINILLA PYCNANTHA sp. nov. § Eumedinilla.

Frutex epiphyticus, ramulis inflorescentiisque dense ciliato-villosis, ramis teretibus, glabris, nodis barbatis; foliis oppositis, petiolatis, in paribus distincte inaequalibus, oblongo-ellipticis, 10 ad 19 cm longis, 4.5 ad 7.2 cm latis, utrinque glabris, apice acuminatis, basi subacutis ad acutis, 7-plinerviis, reticulis obsoletis; inflorescentiis terminalibus, 4 ad 7.5 cm longis, cylindricis, pedunculatis, densifloris; floribus 5-meris, calycibus dense setosis, bracteolis conspicuis.

An epiphytic shrub, the branches terete, glabrous, grayish, 3 to 4.5 mm in diameter, bearded at the nodes. Leaves opposite, in distinctly unequal pairs, oblong-elliptic, subcoriaceous, 10 to 19 cm long, 4.5 to 7.2 cm wide, glabrous on both surfaces, or the young ones somewhat pubescent on the nerves beneath, green, shining, shortly acute acuminate, base subacute to acute, 7-plinerved, the reticulations obsolete; petioles glabrous, or the younger ones densely ciliate-villose, 1.5 to 4.5 cm long. Ra-

cemes spikelike, cylindric, very dense, axillary, 4 to 7.5 cm long, 2.4 to 3 cm in diameter, pedunculate, the peduncles densely ciliate-villose, 1.5 to 2.5 cm long; flowers 5-merous; calyx in fruit densely ciliate-setose, cup-shaped, 5 to 7 mm long, 4 to 6 mm in diameter, with 5 minute teeth; pedicels 2 to 3 mm long, densely ciliate-setose; bracts red, more or less ciliate outside and on the margins, glabrous inside, oblong to oblanceolate, 15 to 22 mm long, 4 to 8.5 mm wide, acute.

LUZON, Nueva Vizcaya Province, Mount Alzapan, *Bur. Sci. 45580 Ramos and Edaño*, May 24, 1925, on tree trunks on slopes in the mossy forest, altitude about 1,600 meters.

A species characterized by it dense cylindric inflorescences, and its conspicuously bracteolate flowers, the peduncles, branchlets, and younger petioles being densely ciliate-villose.

MEDINILLA RADICIFLORA sp. nov.

Frutex circiter 2 m altus, ramis ramulisque teretibus, dense pallide stellato-tomentosis; foliis petiolatis, chartaceis, oppositis, late ellipticis, 15 ad 24 cm longis, 8.5 ad 13.5 cm latis, 11- ad 14-plinerviis, acute acuminatis, basi obtusis ad cordulatis, supra glabris, subtus densissime stellato-tomentosis; inflorescentiis e radicibus oriundis, usque ad 16 cm longis, densis, erectis, dichotome multiramosis; floribus 4-meris, pedicellis usque ad 1 cm longis; staminibus 8, inaequalibus; bracteolis conspicuis.

A shrub about 2 m high, the branches and branchlets terete, densely covered with pale stellate-tomentose hairs, the branchlets about 5 mm in diameter. Leaves opposite, broadly elliptic, chartaceous, 15 to 24 cm long, 8.5 to 13.5 cm wide, the younger ones very densely covered on both surfaces with pale stellate-tomentose hairs, the older ones glabrous on the upper surface, olivaceous-green above, pale brownish beneath, acutely acuminate, the base obtuse to slightly cordate, 11- to 14-plinerved, the nerves prominent, curved, ascending, the primary reticulations somewhat distinct; petioles very densely stellate-tomentose, 1 to 3 cm long. Cymes borne on the roots, erect, densely and many-flowered, repeatedly dichotomously branched, 7 to 16 cm long, up to 14 cm wide, shortly peduncled or the glabrous peduncles up to 7 cm in length, the younger parts sparingly stellate-pubescent. Flowers 4-merous, about 1.6 cm long, their pedicels up to 1 cm long, stellate-tomentose, the bracteoles conspicuous, membranaceous, stellate-tomentose outside, lanceolate to oblong-lanceolate, narrowed to the acute apex, base obtuse, 1.2 to 1.5 cm long, about 0.5 cm wide. Calyx urceolate, 4-toothed, stellate-

tomentose outside, 8 to 10 mm long, 4 to 5 mm in diameter, the teeth triangular, acute, 1.25 to 1.5 mm long. Petals 4, purplish, glabrous, obovate, the somewhat rounded apex with one or two minute notches, 10 to 11 mm long, about 8 mm wide at the widest portion. Stamens 8, unequal, the longer ones about 12 mm long, the shorter ones about 10 mm long; anthers of the longer stamens about 7 mm long, of the shorter ones about 6 mm long, both types of anthers slender, slightly curved or nearly straight, lanceolate, acute, the dorsal appendage about 0.5 mm long, the anterior ones subglobose, stout, blunt, about 0.75 mm long.

MINDANAO, Davao Province, Limot (Mount Mayo), *Bur. Sci. 49544 Ramos and Edaño*, May 24, 1927, along damp forested streams, altitude about 750 meters.

A species with vegetative characters somewhat resembling those of *Medinilla venosa* Blume, differing very strikingly in its densely flowered, repeatedly dichotomous inflorescences which are borne on the roots.

Bur. Sci. 49044 Ramos and Edaño, from Mati, Davao Province, probably represents a form of the same species, differing in its smaller, narrowly elliptic leaves, 10.5 to 20 cm by 5 to 9 cm, with acutely attenuate apices, and its smaller inflorescences, 5 to 8 cm long, which are borne on the trunk.

MEDINILLA SULCATA sp. nov. § Eumedinilla.

Frutex scandens, epiphyticus, glaber; ramis ramulisque 8-angulatis, 4 ad 6 mm diametro; foliis verticillatis, oblongo-ellipticis, 6.5 ad 11 cm longis, 3 ad 5.7 cm latis, 5-plinerviis, apice acuminatis, basi acutis; inflorescentiis fasciculatis, breviter pedunculatis vel sessillibus, paucifloris; floribus 6-meris, pedicellis filiformibus, 10 ad 17 mm longis; staminibus 12, inaequalibus.

A scandent, epiphytic, glabrous shrub; the branches and branchlets distinctly 8-angled or sulcate, 4 to 6 mm in diameter. Leaves in whorls of 4 at each node, oblong-elliptic, 6.5 to 11 cm long, 3 to 5.7 cm wide, membranaceous, when dry brittle, fleshy when fresh, glabrous on both surfaces, somewhat rugose beneath, apex acutely acuminate, base acute, 5-plinerved, the external nerves slender and somewhat obscure; petioles purple, 10 to 20 mm long. Flowers 6-merous, axillary or in the axils of fallen leaves, 2 to 5 in a fascicle, the fascicles sometimes on peduncles up to 2 mm long; the bracts and bracteoles deciduous or none; pedicels very slender, 10 to 17 mm in length; calyx cup-shaped, truncate, minutely 6-denticulate, glabrous, 4 to 4.5 mm

in diameter; petals 6, membranaceous, glabrous, oblong-obovate, about 11 mm long, 7.5 mm wide, the apex with a minute apiculum at the notch; stamens 12, unequal, the longer ones about 13 mm long, the shorter ones about 11 mm long; anthers on the longer stamens about 7 mm long, of the shorter ones about 6 mm long, both types of anthers slender, somewhat curved or straight, lanceolate, acute, the dorsal appendage slender, about 0.75 mm long, the anterior ones subglobose, stout, blunt, about 1 mm long.

LUZON, Cagayan Province, Pañablanca, *Bur. Sci. 46549 Ramos and Edaño*, April 2, 1926, on trees, along forested streams, at low altitudes.

A species probably belonging in the group with *Medinilla verticillata* Merrill, differing strikingly in its angled and sulcate branches and branchlets and in its fascicled, slenderly pedicelled flowers.

MEDINILLA WENZELII sp. nov. § Eumedinilla.

Frutex epiphyticus, glaber; ramis teretibus, ramulis angulatis, sulcatis; foliis verticillatis, quaternis, coriaceis vel subcoriaceis, obovatis ad elliptico-obovatis, acutis ad obtusis, basi cuneatis, 3-nerviis, 3 ad 5.5 cm longis, 1.5 ad 3 cm latis; inflorescentiis axillaribus, 1-floris, pedunculis bracteatis, bracteis oblongo-ellipticis, 5 ad 7 mm longis; floribus 6-meris; calycibus cupulatis, truncatis, post anthesin usque ad 1 cm longis, extus appendicibus paucis brevibus patulis rigidis instructis.

A glabrous epiphytic shrub; the branches terete, light gray, the branchlets angled and sulcate, slender. Leaves whorled, 4 rarely 3 at each node, coriaceous to subcoriaceous, ovate to elliptic-obovate, acute to obtuse, base cuneate, prominently 3-nerved, 3 to 5.5 cm long, 1.5 to 3 cm wide, reticulations obscure or obsolete; petioles 5 to 12 mm long. Inflorescence axillary, simple, 1-flowered, the peduncle 5 mm long or less, bracteate, the bracts 5 to 7 mm long, oblong-elliptic. Calyx cup-shaped, truncate, in bud about 5 mm long, with scattered, rigid, spreading appendages about 1 mm in length. Petals 6, fleshy, broadly rounded-ovate, somewhat apiculate, in young buds about 6 mm long, 7 mm wide. Stamens 12, subequal; anthers 6 to 6.5 mm long (immature). Fruit cylindric-cup-shaped, truncate, about 1 cm long, the calyx tube truncate, somewhat produced, about 8 mm in diameter.

MINDANAO, Surigao Province, Tubud, Placer, *C. A. Wenzel 3021* (type in the herbarium of the University of California),

August 1, 1927, epiphytic on large forest trees at an altitude of about 150 meters.

A curious species, the vegetative characters resembling somewhat those of *Medinilla malindangense* Merrill, strongly characterized by its solitary 6-merous flowers, the calyx tube bearing characteristic, scattered, spreading, rigid appendages about 1 mm in length. By Cogniaux's arrangement of the species it falls in the group with *Medinilla crassinervia* Blume but is remote from all the described species in this assemblage.

Genus MEMECYLON Linnaeus

MEMECYLON AZURINII sp. nov.

Frutex glaber, 1 ad 1.5 m altus; ramis teretibus, laevis, 6 ad 7 mm diametro; ramulis teretibus, minute distanter verrucosis; foliis oblongis, crassissime coriaceis, 21 ad 31 cm longis, 6.5 ad 12 cm latis, apice obtusis ad retusis, basi rotundatis, sessilibus, utrinque glabris nitidisque; nervis lateralibus utrinque circiter 21, tenuibus, subdistinctis, marginalibus aequaliter conspicuis, reticulis obsoletis; infructescentiis terminalibus axillaribusque, pedunculatis, paucifloris, 6 ad 8 cm longis; fructibus globosis, 6 ad 7 mm diametro.

A glabrous shrub, 1 to 1.5 m high; the branches terete, smooth, 6 to 7 mm in diameter; the branchlets terete, reddish brown, minutely and distinctly verrucose. Leaves sessile, oblong, very thickly coriaceous, olivaceous-brown, glabrous and shining on both surfaces, 21 to 31 cm long, 6.5 to 12 cm wide, pinnately nerved, the midrib reddish brown, very prominent; lateral nerves about 21 on each side of the midrib, somewhat obscure, anastomosing with the equally distinct marginal veins, the reticulations obsolete, apex obtuse to retuse, base rounded. Infructescence terminal and axillary, peduncled, 6 to 8 cm long, about as wide, the peduncles and branches subglabrous or slightly pubescent; fruits globose, lilac or red, black when dry, 6 to 7 mm in diameter, their pedicels slender, glabrous, 2 to 3 mm long, subtended by numerous minute bracteoles.

LUZON, Isabela Province, Bagao, *For. Bur. 29372 Azurin*, March, 1923 (type in the herbarium of the University of California), in forests, altitude about 100 meters; local name, *casigay* (Negr.); Mount Moises, *Bur. Sci. 47305 Ramos and Edaño*, March 4, 1926, along forested streams, altitude about 900 meters.

This species does not closely resemble any previously described form, being remarkably well characterized by its large, sessile, oblong, very thickly coriaceous leaves, which are obtuse to retuse at the apex and rounded at the base, and by its minutely verruculose branchlets.

Genus OSBECKIA Linnæus

OSBECKIA LUZONIENSIS sp. nov. § Asterostoma.

Frutex erectus, circiter 1 m altus; ramis viridibus, glabris, subobscure tetragonis, 3 ad 4.5 mm diametro, ramulis tetragonis, parcissime adpresse strigosis; foliis membranaceis, viridibus, supra disperse adpresse strigosis, subtus ad nervis nervulisque parcissime striolatis, 6.5 ad 12.5 cm longis, 1.5 ad 3 cm latis, lanceolatis, apice tenuiter acute attenuatis, basi acutis, 5-nerviis; floribus paucis, terminalibus, circiter 3.5 cm longis, 3 cm diametro; calycibus ovoideis, viridibus, perspicue dense pedicellatim stellato-setosis, 2 ad 2.5 cm longis, circiter 1.5 cm diametro; petalis 5, violaceis, circiter 2 cm longis, 1.5 cm latis obovatis, rotundatis; staminibus 10, aequalibus, circiter 2 cm longis; antheris lineari-lanceolatis, haud curvatis, circiter 10.5 mm longis.

An erect shrub about 1 m high, the smooth branches subobscurely 4-angled, green, glabrous, 3 to 4.5 mm in diameter, the branchlets sparsely appressed strigose; leaves membranaceous, lanceolate, green, attenuate, apex acutely acuminate, base acute, 6.5 to 12.5 cm long, 1.5 to 3 cm wide, above scattered striolate, beneath on the nerves and veinlets sparingly appressed strigose, 5-nerved, the nerves and reticulations distinct; petioles sparingly appressed strigose, 4 to 9 mm long. Flowers terminal, solitary or in threes, about 3 cm in diameter, their pedicels slender, 1 to 2 cm long; bracts about 9.5 mm long, 5 mm wide, ovate, caudate, ciliate; calyx ovoid, green, 2 to 2.5 cm long, about 1.5 cm in diameter, covered with stalked stellate setæ, the teeth stellately hairy, linear-lanceolate, about 10 mm in length; petals 5, violet, about 2 cm long, 1.5 cm wide, obovate, rounded; stamens 10, equal, the anthers about 10.5 mm long, linear-lanceolate, not curved, with 2 tubercles, the connectives very slightly produced, the filaments about as long as the anthers; ovary ovoid, 5-celled, with 10 short, papery lobes about the apex, and ending in a setose point.

LUZON, Tayabas Province, Mount Aizapan, *Bur. Sci. 45719 Ramos and Edaño*, June 6, 1925, a very rare plant in the open places and along streams, at low altitudes.

A species strongly characterized by being nearly smooth, not harsh, sparingly striolate or strigose, and its ovoid, densely stellate-setose calyces, the tufts being conspicuously pedicillate.

MYRSINACEÆ

Genus DISCOCALYX Mez

DISCOCALYX XIPHOPHYLLA sp. nov.

Frutex dioicus, glaber, saltem 1 m altus; foliis numerosis, lineari-lanceolatis, 13 ad 25 cm longis, 0.8 ad 1.5 cm latis, integris, olivaceis, chartaceis, nitidis, utrinque reticulatis, longe acute acuminatis, basi attenuatis, nervis numerosis, subobscuris; inflorescentiis paniculatis, paucifloris, 5 ad 10 cm longis in ramis specialibus lateralibus tenuibus usque ad 20 cm longis dispositis; floribus ♂ paucis, 1.25 ad 1.5 mm diametro, tenuiter pedicellatis, sepalis circiter 0.7 mm longis, acuminatis; petalis punctatis, circiter 1.25 mm longis; fructibus circiter 5 mm diametro.

A glabrous diœcious shrub, at least 1 m high, simple or sparingly branched, the branches terete, the branchlets smooth, 2 to 3 mm in diameter. Leaves numerous, pseudoverticillately crowded at the top and at the close of a season's growth, linear-lanceolate, 13 to 25 cm long, 0.8 to 1.5 cm wide, entire, chartaceous, olivaceous, shining, glabrous, punctulate on both surfaces, narrowed to the acutely acuminate apex, base attenuate; lateral nerves about 25, slender, distinct but not more prominent than the primary reticulations; petioles thickened, up to 1 cm long. Special lateral branches bearing the inflorescences slender, 15 to 20 cm long, simple or with one or two 1 to 4 cm long branches near the top, sometimes with a few, small, leaflike bracts 1 to 1.8 cm long, on the lower part; branchlets with numerous scars, slightly thickened, bearing one or few very slender, few-flowered, 5 to 10 cm long panicles at or near their apices. Staminate flowers few, reddish, 1.25 to 1.5 mm in diameter, 5-merous, their pedicels very slender, 6 to 8 mm long, subtended by very minute bracteoles; sepals about 0.75 mm long, punctate, oblong, obtuse; petals united below, oblong-obovate, rounded, punctate, about 1.25 mm long; stamens 5, subsessile, anthers oblong, obtuse, about 0.75 mm long. Fruit subglobose, about 5 mm in diameter, when dry brown and with distinct but shallow longitudinal grooves; the punctate persistent sepals ovate-lanceolate, acuminate, 0.75 to 1 mm long.

LUZON, Tayabas Province, Mount Alzapan, *Bur. Sci 45678 Ramos and Edaño*, June 6, 1925, in forests, altitude about 1,800 meters.

A species probably belonging in the group with *Discocalyx linearifolia* Elmer but totally different in its vegetative and inflorescence characters. It notably differs from *D. angustissima* Merrill in its entire leaves.

Genus MAESA Forskål

MAESA RAMOSII sp. nov. § Eumaesa.

Frutex glaber, circiter 1 m altus, ut videtur erectus; ramulis teretibus, lenticellatis; foliis ovato-lanceolatis, chartaceis ad subcoriaceis, 7.5 ad 10.5 cm longis, 2.4 ad 3.2 cm latis, perspicue acute attenuatis, basi acutis, margine distincte subrepando-dentatis; nervis utrinque 5 vel 6, perspicuis; inflorescentiis axillaribus, 1.5 ad 3.3 cm longis, anguste paniculatis; floribus paucis, breviter pedicellatis; sepalis orbiculari-ovatis, rotundatis, integris, haud lineatis, margine ciliatis, circiter 1 mm longis; corolla circiter 2 mm longa, lobis usque ad medium connatis, orbiculari-ovatis, rotundatis, haud lineatis, integris.

A glabrous, apparently erect shrub at least 1 m high, the branches terete, reddish brown to brown, prominently lenticellate. Leaves ovate-lanceolate, firmly chartaceous to subcoriaceous, 7.5 to 10.5 cm long, 2.4 to 3.2 cm wide, the upper surface brownish olivaceous, the lower surface paler, apex prominently and acutely acuminate, base acute, margin distinctly subrepand-dentate; lateral nerves 5 or 6 on each side of the midrib, prominent, curved, ascending, anastomosing; petioles slender, 1.6 to 2.2 cm long. Panicles axillary, glabrous or slightly puberulent, 1.5 to 3.3 cm long; flowers 5-merous, white, not numerous, their pedicels slightly puberulent, about 1 mm long, the bracts spathulate-lanceolate, 2 to 4 mm long, the bracteoles ovate-lanceolate, acute, cymbiform, about 1 mm long; sepals orbicular-ovate, rounded, entire, not lineate, the margins ciliate, about 1 mm long; corolla 5-lobed, about 2 mm long, the lobes connate to the middle, orbicular-ovate, rounded, not lineate, entire; stamens inserted about the middle of the tube, the filaments about twice as long as the anthers.

LUZON, Isabela Province, Mount Moises, *Bur. Sci. 47272 Ramos and Edaño*, March 4, 1926, in forests, altitude about 1,300 meters.

A species allied to *Maesa laxa* Mez, but distinguished by its smaller ovate-lanceolate, conspicuously acuminate leaves and its short, few-flowered inflorescences.

OLEACEÆ

Genus JASMINUM Tournefort

JASMINUM OLIGANTHUM sp. nov. § Unifoliolata.

Frutex scandens, glaber, ramis teretibus, laevis, 2 ad 3 mm diametro; ramulis tenuibus, circiter 1 mm diametro; foliis ovato-lanceolatis, 6 ad 9.5 cm longis, 1.8 ad 3.7 cm latis, subchartaceis, utrinque nitidis, concoloribus, glabris, acute acuminatis, basi acutis, nervis utrinque 5 vel 6, subtus perspicuis, arcuato-anastomosantibus; petiolo breviter parce puberulo, 5 ad 10 mm longo; inflorescentiis terminalibus axillaribusque, paucifloris; floribus 1 ad 3, albidis, 4.5 ad 5 cm longis, longe (2 ad 2.5 cm) pedicellatis; calycis lobis 6, linearibus, acutis, tenuibus, 2 ad 4 mm longis; corollae tubo 1.6 ad 2 cm longo, lobis 9 ad 11, linearibus, 14 ad 17 mm longis, 2 ad 3 mm latis; fructibus globosis ad ellipsoideis, 9 ad 12 mm longis.

A scandent, glabrous or nearly glabrous shrub, the branches terete, smooth, glabrous, 2 to 3 mm in diameter, the branchlets slenderer. Leaves ovate-lanceolate, 6 to 9.5 cm long, 1.8 to 3.7 cm wide, subchartaceous, shining and glabrous on both surfaces, the apex sharply acuminate, base acute; lateral nerves 5 or 6 on each side of the midrib, prominent beneath, ascending, arched-anastomosing, the reticulations lax; petioles minutely puberulent or glabrous, 5 to 10 mm long. Inflorescence terminal and axillary, mostly 3-flowered, the rachis minutely puberulent, slender, the bracts linear-lanceolate, minutely puberulent, 1.5 to 2 mm long; flowers 1 to 3, their pedicels slender, 2 to 2.5 cm long; calyx usually 6-lobed, the tube cylindric, glabrous, the lobes linear, acute, slender, their margins minutely ciliate, 2 to 4 mm long, two sometimes longer than the others; corolla white, the tube slender, 1.6 to 2 cm long, 1 to 1.25 mm in diameter, the lobes 9 to 11, linear, 1.4 to 1.7 cm long, 2 to 3 mm wide. Anthers linear, subsessile, about 5 mm long, the filaments very short. Ovary sparsely pubescent at the apex. Fruits usually simple, sometimes didymous, the carpels globose to ellipsoid, black when dry, 9 to 12 mm long, 7 to 9 mm in diameter, their pedicels slender, 1.5 to 2.5 cm long.

LUZON, Tayabas Province, Casiguran, *Bur. Sci. 45541 Ramos and Edaño*, June 11, 1925, in damp forests, along streams at

low altitudes; Isabela Province, San Mariano, *Bur. Sci. 46957, 47118 Ramos and Edaño,* February 18, 1926, in forests at low altitudes.

A species obviously allied to *Jasminum bifarium* Wallich, and very close to *Jasminum ixoroides* Elmer; distinguished from the latter by its long pedicels and longer corolla lobes.

Genus LIGUSTRUM Tournefort

LIGUSTRUM STENOPHYLLUM sp nov. § Sapdrupaceæ, Robustæ.

Frutex erectus, ramulis inflorescentiisque, exceptis glaber, ramis teretibus, glabris, lenticellatis, pallidis, 1.5 ad 3 mm diametro, ramulis breviter pubescentibus; foliis lanceolatis, 3 ad 8.5 cm longis, 0.7 ad 1.4 cm latis, utrinque attenuatis, subcoriaceis, tenuiter acuminatis, basi cuneatis, nervis lateralibus utrinque 6 vel 7, tenuibus; inflorescentiis pyramidato-paniculatis, 6 ad 9 cm longis, 5 ad 7.5 cm latis, dense pubescentibus, multifloris; floribus albidis, numerosis; calycibus 1.5 ad 2 mm longis, glabris, crenatis; corolla tubo 2 ad 2.5 mm longo, lobis tubo subaequantibus, oblongis, acutis.

A shrub about 3 m high, glabrous except the branchlets and inflorescences, the branches slender, terete, glabrous, pale, lenticellate, 1.5 to 3 mm in diameter, the branchlets shortly pubescent; leaves lanceolate, 3 to 8.5 cm long, 0.7 to 1.4 cm wide, subequally narrowed at both ends, subcoriaceous, the apex slenderly acuminate, base cuneate; lateral nerves 6 or 7 on each side of the midrib, slender; petioles glabrous 3 to 5 mm long. Panicles pyramidal, many-flowered, 6 to 9 cm long, 5 to 7.5 cm wide, densely pubescent; bracts linear, acute, pubescent, the lower ones foliaceous, 5.5 to 11 mm long, 0.75 to 1.5 mm wide; flowers 4-merous, numerous; bracteoles ciliate on the margin, 1 to 2 mm long; pedicels glabrous, or pubescent at the base, 1.5 to 3 mm long; calyx 1.5 to 2 mm long, glabrous, the rounded lobes short; corolla 4.5 to 5 mm long, glabrous, the lobes about as long as the tube, oblong, acute; anthers oblong, about 2 mm long; the filaments longer than the corolla lobes.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 47153 Ramos and Edaño,* March 16, 1926; Mount Moises, *Clemens 16782,* April 16 to 23, 1926, along forested streams, altitude about 400 meters.

A species apparently allied to *Ligustrum massalongianum* Visiani, of the Khasia Hills, Assam, India. It differs in its pubescent bracts and ciliate bracteoles, and its flowers having

relatively longer pedicels and filaments. For a recent monograph of *Ligustrum*, see Mansfeld.[4]

Genus LINOCIERA Swartz

LINOCIERA CLEMENTIS sp. nov.

Frutex erectus, glaber, ramis 3 ad 5 mm diametro; foliis oblanceolatis, 10 ad 16 cm longis, 1.5 ad 3.3 cm latis, chartaceis ad subcoriaceis, apice acute acuminatis, basi cuneatis, nitidis, subtus perspicue punctulatis, nervis lateralibus tenuibus, subperspicuis; inflorescentiis terminalibus, 7 ad 7.5 cm longis, cymoso-paniculatis; floribus 3 ad 4 mm longis; petalis liberis, 3.5 ad 3.75 mm longis.

An erect, glabrous shrub, the branches 3 to 5 mm in diameter. Leaves oblanceolate, shining, prominently punctulate beneath, apex acutely acuminate, narrowed to the cuneate base, 10 to 16 cm long, 1.5 to 3.3 cm wide, chartaceous to subcoriaceous, the midrib reddish when dry; lateral nerves slender, somewhat prominent on both surfaces, about 10 on each side of the midrib; petioles very short. Inflorescence terminal, cymose-paniculate, 7 to 7.5 cm long, 4.5 to 5 cm wide, glabrous; bracts glabrous, oblong-oblanceolate, 6 to 11.5 mm long, 2 to 4 mm wide. Flowers white, reddish brown when dry, 4-merous, 3 to 4 mm long, the pedicels glabrous, 1 to 2 mm long; bracteoles ovate, 0.75 to 1 mm long; calyx 1.5 to 1.75 mm long, the lobes ovate, acute, sparsely ciliate on the margin, about half as long as the calyx; petals nearly free, linear, acute, 3.5 to 3.75 mm long; ovary oblong-ovoid; style very short or none.

LUZON, Isabela Province, Mount Moises, above Ambabu, *Clemens 16785* (type), *16784* (with galls), April 15 and 16, 1926. Type in the herbarium of the University of California.

A very characteristic species recognized by its oblanceolate, punctulate leaves.

LINOCIERA SCANDENS sp. nov.

Frutex scandens, glaber, ramis teretibus, laevis, 3 ad 4 mm diametro; foliis ovatis, 4.5 ad 7.5 cm longis, 2 ad 4.3 cm latis, coriaceis, nitidis, minute nigro-puncticulatis, nervis lateralibus obscuris vel obsoletis, acute ad subobtuse acuminatis, basi acutis; petiolo glabro, 10 ad 13 mm longo. Inflorescentiis terminalibus lateralibusque, laxis, 3- vel 4-pinnatim-paniculatis, 8.5 ad 13 cm longis, ramis paucis patulis, inferioribus 4 ad 5 cm longis, floribus ♂ 4-meris, 2 ad 3 mm longis, pedicellis glabris, 2 ad 3 mm

[4] Engl. Bot. Jahrb. 59 (1924) Beibl. 132: 19.

longis; corrolla 2 ad 2.25 mm longa, lobis ad 1.25 mm longis, oblongis, subacutis.

A glabrous woody vine, the branches glabrous, terete, smooth, reddish brown, 2 to 4 mm in diameter, internodes elongated. Leaves ovate, 4.5 to 7.5 cm long, 2 to 4.3 cm wide, coriaceous, glabrous and shining on both surfaces, with numerous minute black dots on both surfaces, pale when dry; lateral nerves obscure or obsolete, apex acutely to subobtusely acuminate, base acute; petioles 10 to 13 mm long. Inflorescence terminal and lateral, 3- or 4-pinnate-paniculate, 8.5 to 13 cm long, the few branches spreading at right angles, the lower ones 4 to 5 cm long, minutely puberulent; bracts lanceolate, acute, minutely puberulent, 1.5 to 3 mm long, the lower ones up to 9 mm long. Flowers green, dark brown when dry, 4-merous, 2 to 3 mm long, the pedicels glabrous, 2 to 3 mm long; bracteoles ovate-lanceolate, acute, minutely puberulent, about 1 mm in length; calyx about 1 mm long, the lobes half as long as the tube, triangular-ovate, acute, glabrous; corolla 2 to 2.25 mm long, the lobes 1 to 1.25 mm long, oblong, subacute, somewhat fleshy; anthers subsessile, 1.5 to 1.75 mm long, erect, oblong, bilobed at the apex, connective very broad.

LUZON, Nueva Vizcaya Province, Mount Alzapan, *Bur. Sci. 45740 Ramos and Edaño*, May 21, 1925, rare on forested slopes, altitude about 1,700 meters.

A species radically different from any of the other Philippine members of the genus. It is manifestly allied to the Bornean *Linociera macrobotrys* Merrill, differing in its scandent habit and its prominently acuminate leaves and longer petioles.

LOGANIACEÆ

Genus GENIOSTOMA Forster

GENIOSTOMA FASCICULATA sp. nov.

Frutex circiter 2 m altus, inflorescentiis exceptis glaber; foliis chartaceis ad subcoriaceis, oblong-ellipticis ad lanceolatis, nitidis, in siccitate nigris, 10 ad 15.5 cm longis, 2 ad 4 cm latis, apice acute acuminatis, basi acutis, nervis lateralibus utrinque 6 ad 8, tenuibus, reticulis obsoletis; floribus fasciculato-cymosis, pedicellatis, pubescentibus; corollae tubo circiter 3 mm longo, 3 mm diametro, lobis reflexis, oblongo-ovatis, subacutis, extus minute hirtellis, intus minute glandulosis, 2 ad 2.25 mm longis. Fructibus ellipsoideis vel ovoideo-ellipticis, circiter 7 mm longis, apiculatis.

A shrub about 2 m high, glabrous throughout except the inflorescences, the branches terete, straw-colored, the young branchlets, leaves, petioles, and inflorescences black when dry. Leaves chartaceous to subcoriaceous, oblong-elliptic to lanceolate, shining, apex acutely acuminate, base acute, 10 to 15.5 cm long, 2 to 4 cm wide; lateral nerves 6 to 8 on each side of the midrib, slender, the reticulations obsolete; petioles 1.5 to 2 cm long. Flowers in short axillary, fascicled cymes, up to 15 in each axil, about 3 mm long, their pedicels 3 to 4 mm long, slender; minutely hirtellous bracteolate, bracteoles ovate, up to 2 mm long; sepals ovate, acute, minutely hirtellous externally and on the margins, 1.75 to 2 mm long; corolla tube glabrous outside, minutely glandular within, about 3 mm long, the lobes reflexed, oblong-ovate, subacute, minutely hirtellous outside, minutely glandular inside, 2 to 2.25 mm long. Fruits black, about 7 mm long, 4 mm in diameter, ellipsoid to ovoid-ellipsoid, apiculate, the apiculum up to 1 mm in length, the pedicels about 5 mm long.

LUZON, Nueva Vizcaya, Mount Alzapan, *Bur. Sci. 45629 Ramos and Edaño*, May 23, 1925, on forested slopes, altitude about 1,000 meters: Isabela Province, Mount Moises, *Clemens 16619*, April, 1926, flowers greenish white.

In general this species resembles *Geniostoma pachyphyllum* Merrill, which is known from fruiting specimen only, differing in its larger leaves and longer petioles. This species is well characterized further by its short, pubescent, few-flowered fascicled cymes, which are crowded in the axils, and by its apiculate fruits.

APOCYNACEÆ

Genus KOPSIA Blume

KOPSIA TRIANGULARIS sp. nov.

Frutex circiter 3 m altus, bracteis calycibusque exceptis glaber; foliis chartaceis ad subcoriaceis, oblongo-lanceolatis ad oblongo-ellipticis, 9.5 ad 15 cm longis, 2 ad 4.5 cm latis, nitidis, obtuse acuminatis, basi cuneatis, nervis utrinque 14 ad 16, cum reticulis utrinque distinctis; inflorescentiis terminalibus, brevibus, pedunculatis, dichotome ramosis, paucifloris, pedunculo circiter 1.5 cm longo; bracteis late ovatis, acutis, minute ciliatis; calycis lobis oblongis ad oblongo-ovatis, 3.5 ad 4 mm longis; corollae tubo circiter 2.5 cm longo, apice leviter incrassato, intus pubescentibus, lobis oblongo-obovatis, 1.75 ad 2 cm longis, 1 ad 1.2 cm latis, rotundatis. Fructibus compressis, triangularis, striatis, circiter 2.4 cm longis, 1.4 cm latis, rostrato-acuminatis.

A shrub about 3 m high, glabrous throughout except the bracts and calyces. Branches pale, somewhat rugose when dry, about 5 mm in diameter, the ultimate branchlets terete, about 1 mm thick. Leaves chartaceous to subcoriaceous, oblong-lanceolate to oblong-elliptic, 9.5 to 15 cm long, 2 to 4.5 cm wide, grayish olivaceous, shining, narrowed above to obscurely acuminate apex, with a gland at the extreme tip, the base narrowed, cuneate; lateral nerves 14 to 16 on each side of the midrib, slender, ascending, anastomosing with the marginal nerves, distinct on both surfaces, the reticulations very slender, somewhat distinct on both surfaces; petioles very short or almost none, or in the larger leaves up to 6 mm in length. Inflorescence terminal, few-flowered, peduncled, the peduncles about 1.5 cm long, dichotomously branched at their apices. Flowers white, spicately arranged on the short branches, serially falling. Bracts small, broadly ovate, acute, 2.25 to 2.5 mm long, 2 to 2.25 mm wide, imbricate near the apices of the branchlets, somewhat scattered below, somewhat keeled, the margins minutely ciliate. Calyx lobes oblong to oblong-ovate, with a gland on the beak near the top, the margins minutely ciliate, 3.5 to 4 mm long, 2.5 to 3 mm wide. Corolla tube cylindric, glabrous outside, somewhat villose inside, about 2.5 cm long, slightly inflated at the top, the lobes spreading oblong-obovate, rounded, 1.75 to 2 cm long, 1 to 1.2 cm wide. Anthers lanceolate, apiculate, the bases rounded, about 2.25 mm long, the filaments very short. Disk glands subulate, about 1.25 mm long. Carpels glabrous. Fruit compressed, somewhat striate, triangular, about 2.4 cm long, 1.4 cm wide, the dorsal margin straight, the apex rostrate-acuminate, base cuneate.

MINDANAO, Surigao Province, *C. A. Wenzel 2648* (type in the herbarium of the University of California), May 17, 1927, along the shore of Lake Manuel, near Surigao, altitude about 150 meters.

A species apparently allied to *Kopsia turanensis* King and Gamble, differing essentially in its terminal, peduncle inflorescences and larger flowers.

Genus VOACANGA Thouars

VOACANGA DOLICHOCALYX sp. nov.

Frutex circiter 3 m altus, glaber; foliis anguste oblongis ad anguste oblongo-oblanceolatis, breviter acuminatis, acutis ad obtusis, basi angustatis, acutis, 10.5 ad 17 cm longis, 3 ad 5

cm latis, nervis utrinque 8 ad 10; petiolo 1.5 ad 2.3 cm longo, basi subvaginato; inflorescentiis terminalibus axillaribusque, longe pedunculatis, dichotomis, paucifloris; calycis tubo 3 ad 3.6 cm longo, breviter 5-lobato; corolla alba, tubo 3 ad 3.8 cm longo, lobis elliptico-ovatis vel late elliptico-ovatis, 3 ad 3.5 cm longis, 1.6 ad 2 cm latis.

A glabrous shrub about 3 m high; the branchlets somewhat angular when dry, smooth; leaves narrowly oblong to narrowly oblong-oblanceolate, 10.5 to 17 cm long, 3 to 5 cm wide, chartaceous, apex shortly and rather abruptly acuminate, the tip acute to obtuse, base narrowed, acute; lateral nerves 8 to 10 on each side of the midrib, distant, slender, distinct, the reticulations obscure to obsolete; petioles 1.5 to 2.3 cm long; the base somewhat sheating; inflorescence paniculate, terminal and axillary, dichotomously branched; the peduncles 4.2 to 6.5 cm long, the flowers fairly large, white, not crowded at the ends of the branches; calyx 3 to 3.6 cm long, cylindric, the lobes 5, subimbricate, ovate, apex obtuse to rounded, 2 to 3 mm long, glands at the base of the tube within not numerous; corolla tube 3 to 3.8 cm long, the lobes spreading, elliptic-ovate to broadly elliptic-ovate, obtuse to rounded, 3 to 3.5 cm long, 1.6 to 2 cm wide; anthers narrowly lanceolate, acuminate, 5.5 to 5.75 mm long.

LUZON, Tayabas Province, Casiguran, *Bur. Sci. 45264 Ramos and Edaño*, May 5, 1925, in secondary forest, at low altitudes: Ilocos Norte Province, Bangui, *Bur. Sci. 43584 McGregor*, 1923.

A species closely allied to *Voacanga globosa* (Blanco) Merrill, but with much longer calyx tube and somewhat larger flowers.

VOACANGA LATIFOLIA sp. nov.

Frutex circiter 2 m altus, glaber; ramis teretibus junioribus plus minusve sulcatis, laevis, 6 ad 7 mm diametro; foliis oblongo-ellipticis ad oblongo-obovatis, abrupte breviter acute acuminatis, basi acutis, 23 ad 30 cm longis, 9.5 ad 12.5 cm latis, nitidis, subcoriaceis, nervis utrinque 10 ad 12, curvatis, subtus perspicuis; petiolo 2 ad 2.3 cm longo, basi vaginato; inflorescentiis longe pedunculatis, dichotomis, paucifloris; calycis tubo cylindrico, 4 ad 5.5 cm longo, haud profunde 5-lobato, intus ad basi multiglanduloso; corolla alba, tubo 4.5 ad 6 cm longo, lobis late rotundato-ovatis, usque ad 4 cm longis.

A glabrous shrub about 2 m high; the branches terete, the younger ones when dry more or less sulcate, smooth, 6 to 7 mm thick. Leaves oblong-elliptic to oblong-obovate, 23 to 30 cm long, 9.5 to 12.5 cm wide, subcoriaceous, shortly and abruptly

acute-acuminate, base acute, shining on both surfaces; nerves 10 to 12 on each side of the midrib, curved, prominent, the reticulations obscure; petioles 2 to 2.3 cm long, the base inflated. Inflorescence terminal and axillary, dichotomously branched; the peduncles 7 to 9.5 cm long; flowers few, large, white, near the ends of the branches; calyx cylindric, 4 to 5.5 cm long, lobes 5, oblong to narrowly oblong, 4 to 6.5 mm long, the glands at the base of the tube within very numerous; corolla tube 4.5 to 6 cm long, cylindric, somewhat inflated above, the lobes spreading, orbicular to obovate, obtuse to rounded, up to 4 cm in diameter; anthers narrowly lanceolate, acuminate, 9 to 10 mm long.

LUZON, Isabela Province, San Mariano, *Bur Sci. 47070 Ramos and Edaño*, February 15, 1926, in damp forest, at low altitudes.

This species resembles *Voacanga megacarpa* Merrill in vegetative characters, but differs in its much longer calyx tube, which is not split nearly to the base, and in its longer anthers.

Genus WILLUGHBEIA Roxburgh

WILLUGHBEIA ELLIPTIFOLIA sp. nov.

Frutex scandens, glaber; foliis subcoriaceis, ellipticis, perspicue acute acuminatis, basi late acutis, 10 ad 17.5 cm longis, 5 ad 10 cm latis, nervis utrinque 13 vel 14; inflorescentiis depauperato-paniculatis, axillaribus et subterminalibus, pauci-floris, 4 ad 5 cm longis, floribus glabris, circiter 8 mm longis.

A scandent shrub without tendrils, glabrous throughout, 3 to 5 m high. Branches slender, terete, pale brown, lenticellate, about 5 mm in diameter, the branchlets slender, terete, reddish brown, smooth. Leaves elliptic, 10 to 17.5 cm long, 5 to 10 cm wide, rather abruptly and acutely acuminate, the acumen 1 cm long or less, the base broadly acute, subcoriaceous, pale olivaceous-green to light brown above, paler beneath when dry; lateral nerves 13 or 14 on each side of the midrib, slender, spreading, distinct on both surfaces, the reticulations lax, obscure to obsolete; petioles about 10 mm in length. Inflorescences axillary and subterminal, depauperate-paniculate, few-flowered, 4 to 5 cm long including the peduncles, the peduncles not more than 2 cm long; the bracts small, ovate, subacute or obtuse, the margins minutely ciliate, about 1.5 mm long, the bracteoles similar but smaller. Flowers white and yellow, about 8 mm long, their pedicels about 2 mm long. Calyx about 2 mm in diameter, the tube very short, the lobes broadly ovate, some-

what rounded, the margins minutely ciliate, 1.25 to 1.5 mm long, about 1 mm wide. Corolla tube cylindric, slender, 6 to 7 mm long, slightly inflated in the middle, glabrous outside, slightly pubescent within, the mouth with fleshy, narrowly oblong, about 1-mm long glands or appendages, the lobes overlapping to the left, twisted to the right, oblong, spreading, about 4 mm long, 2 to 2.5 mm wide. Anthers inserted in the middle of the tube, included, ovate-lanceolate, acutely acuminate, the base rounded, about 1.5 mm long. Ovary 1-celled, ovoid, glabrous, about 1.25 mm long. Fruit unknown.

MINDANAO, Surigao Province, Placer, *C. A. Wenzel 2605* (type in the herbarium of the University of California), *3108*, May and August, 1927, in forests, altitude about 150 meters.

A species in vegetative and floral characters resembling *Willughbeia pauciflora* Merrill, differing in its depauperate-paniculate, glabrous inflorescences.

VERBENACEÆ

Genus CALLICARPA Linnæus

CALLICARPA PACHYCLADA sp. nov.

Frutex circiter 3 m altus; ramulis incrassatis, ramulis et subtus foliis dense tomentosis; foliis eglandulosis, chartaceis ad subcoriaceis, late oblongo-ellipiticis, 27 ad 39 cm longis, 14 ad 21 cm latis, undulato-dentatis, apice acute acuminatis, basi acutis, supra glabris, olivaceis, subtus pallidis, dense subplumoso-stellatis, nervis utrinque circiter 10, valde perspicuis; cymis axillaribus, multifloris, dichotomis, densissime plumoso-stellatis, pedunculatis, 6 ad 8 cm longis, 5 ad 10 cm latis; floribus confertis, breviter pedicellatis; calycibus breviter 4-lobatis, circiter 1.75 mm longis; corolla 4-lobata, 3 ad 3.5 mm longa, 2.5 to 3 mm diametro, lobis 1.25 ad 1.5 mm longis, oblongo-ovatis, obtusis; staminibus 4, exertis antheris oblongis, 1.25 ad 1.4 mm longis; fructibus globosis, glabris, 2 ad 2.5 mm diametro.

A shrub about 3 m high; the thickened branchlets and the lower surface of the leaves densely fulvo-tomentose with rather soft, plumose and stellate hairs; branches terete or somewhat compressed at the nodes, pale grayish. Leaves chartaceous to subcoriaceous, broadly oblong-elliptic, 27 to 39 cm long, 14 to 21 cm wide, undulate-dentate, apex acutely acuminate, base acute, the upper surface olivaceous, glabrous, smooth, shining, the lower surface pale, somewhat yellowish, not at all glandular, very densely stellate-plumose-pubescent; lateral nerves about

10 on each side of the midrib, very prominent, the reticulations distinct; petioles densely tomentose, somewhat angled, 4 to 6 cm long. Cymes axillary, many-flowered, dichotomus, very densely tomentose, pedunculate, 6 to 8 cm long, 5 to 10 cm wide. Flowers crowded, their pedicels 0.5 to 1 mm long; calyx membranaceous, cup-shaped, shortly 4-lobed, tomentose, about 1.75 mm long; corolla 4-lobed, 3 to 3.5 mm long, 2.5 to 3 mm in diameter, the lobes 1.25 to 1.5 mm long, about 1 mm wide, oblong-ovate, obtuse. Stamens 4, exerted, the filaments 4 to 4.5 mm long; anthers oblong, 1.25 to 1.4 mm long. Fruit globose, glabrous, 2 to 2.5 mm in diameter, surrounded at the base by the densely fulvo-tomentose calyx; bracts densely fulvo-tomentose, linear, up to 15 mm long, the bracteoles much shorter.

LUZON, Nueva Vizcaya Province, Mount Alzapan, *Bur. Sci. 45640 Ramos and Edaño*, May 24, 1925, on forested slopes, altitude about 1,600 meters.

A species most closely allied to *Callicarpa magnifolia* Merrill, but with broadly oblong-elliptic, somewhat larger leaves, the margins undulate-dentate and the base acute.

CALLICARPA PLUMOSA sp. nov.

Frutex circiter 2 m altus; indumento ad inflorescentiis et ramulis et subtus foliis ad costa nervisque stellato-plumoso, ramulis angulatis; foliis eglandulosis, subcoriaceis, lanceolatis, 21 ad 34 cm longis, 6 ad 10 cm latis, integris, sursum angustatis, perspicue subfalcato-acuminatis, basi acutis, supra glabris, nitidis, viridibus, subtus densissime pallide stellatis, nervis utrinque 9 vel 10, valde perspicuis, curvatis; cymis axillaribus, multifloris, dichotomis, densissime plumoso-stellatis, pedunculatis, 3.5 ad 5.5 cm longis; floribus breviter pedicellatis; calycibus membranaceis, dense plumoso-stellatis, breviter 4-lobatis, 1.5 ad 1.75 mm longis, 1.5 ad 1.75 mm diametro; corolla 3.5 ad 3.75 mm longa, lobis 0.75 mm longis, oblongo-ovatis, subacutis; staminibus 4, exertis, 5.5 ad 6 mm longis; antheris oblongis, circiter 1.25 mm longis; fructibus globosis, glabris, circiter 2.5 mm diametro.

A shrub about 2 m high; the branchlets and the lower surface of the leaves densely stellate-tomentose with rather soft, plumose and stellate hairs; branches terete or somewhat compressed at the nodes, pale grayish, the plumose indumentum castaneous. Leaves subcoriaceous, lanceolate, 21 to 34 cm long, 6 to 10 cm wide, entire, narrowed upward to the more or less falcate apex, acutely acuminate, base acute, the upper surface green, smooth, glabrous, the lower surface densely pale stellate-pubescent, not

at all glandular, the indumentum on the midrib and nerves plumose, more or less castaneous; lateral nerves distant, 9 or 10 on each side of the midrib, very prominent, curved, the reticulations distinct; petioles densely tomentose, 2 to 3 cm long. Cymes axillary, many-flowered, dichotomous, very densely castaneous-plumose-tomentose, pedunculate, 3.5 to 5.5 cm long; flowers somewhat crowded, their pedicels 0.5 to 1 mm long; calyx menbranaceous, cup-shaped, shortly 4-lobed, densely stellate-plumose, 1.5 to 1.75 mm long and 1.5 to 1.75 cm in diameter; corolla membranaceous, 4-lobed, 3.5 to 3.75 mm long, the lobes 0.75 mm long, about 1 mm wide, oblong-ovate, subacute; stamens 4, exerted, 5.5 to 6 mm long; anthers oblong, about 1.25 mm long; the filaments very slender; style very slender, about 6 mm long. Fruit globose, glabrous, about 2.5 mm in diameter, surrounded for about two-thirds of its length by the calyx.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 46928 Ramos and Edaño,* March 15, 1926, along forested streams, altitude about 400 meters.

A species characterized by its lanceolate, entire leaves, which are green and glabrous above and densely pale stellate-pubescent beneath, the indumentum on its branchlets, and inflorescences being plumose and castaneous.

Genus CLERODENDRON Linnæus

CLERODENDRON PUBIFOLIUM sp. nov.

Frutex erectus, pubescente; foliis oblongo-ellipticis ad oblongo-ovatis, chartaceis, usque ad 17 cm longis, 8.8 cm latis, apice breviter acute acuminatis, basi late acutis, margine integris, supra sparse, subtus dense pilosis, nervis utrinque 5 ad 7, distinctis, distantibus; inflorescentiis terminalibus, umbellato-paniculatis, pedunculatis, densis, multifloris, dense pilosis, 9 ad 14 cm latis; calycibus cupuliformis, 4 ad 4.5 mm longis, 2.5 ad 3.5 mm diametro, dense pubescentibus, truncatis vel minute 5-denticulatis, basi acutis; corollae tubo tenui, cylindrico, minute puberulo, 15 ad 19 mm longo, lobis minute puberulis, obovatis, subrotundatis, 3 ad 4 mm longis, 2 ad 2.5 mm latis; filamentis usque ad 20 mm longis; fructibus ovoideis, glabris, rotundatis vel truncatis, usque ad 1.5 cm longis, 1 cm diametro.

An erect pubescent shrub. Branches terete, the ultimate branchlets somewhat angled. Leaves chartaceous, oblong-elliptic to oblong-ovate, olivaceous-brown, shining and sparsely pilose

above, brown and densely pilose beneath, 7 to 17 cm long, 3.5 to 8.8 cm wide, apex shortly and acutely acuminate, the base cuneate, the margins entire; lateral nerves 5 to 7 on each side of the midrib, prominent, distant, curved, the reticulations lax; petioles densely pilose, 1.5 to 3.2 cm long. Inflorescence terminal, many-flowered, 9 to 14 cm long, umbellate-paniculate, densely pubescent with short hairs; bracteoles acicular, 2 to 4 mm long; peduncles 2.5 to 4.5 cm long. Calyx cup-shaped or funnel-shaped, 4 to 4.5 mm long, 2.5 to 3.5 mm in diameter, truncate or minutely 5-toothed, narrowed to the acute base, densely pubescent. Corolla tube slender, cylindric, minutely puberulent outside, 15 to 19 mm long, the lobes minutely puberulent outside, obovate to suborbicular, 3 to 4 mm long, 2 to 2.5 mm wide. Filaments long-exerted, filiform, up to 20 mm long. Ovary glabrous. Fruits ovoid, rounded or truncate, red when fresh, black when dry, 1.2 to 1.5 cm long, 0.8 to 1 cm in diameter, the persistent calyx somewhat enlarged, 7 to 9 mm long.

MINDANAO, Davao Province, Mount Mayo, *Bur. Sci. 49416 Ramos and Edaño*, April 21, 1927, along streams in secondary forests, altitude about 700 meters.

A species belonging in the group with *Clerodendron sahelangii* Koorders and *C. ellipticifolium* Merrill, differing conspicuously by its pubescent leaves and ovoid fruits.

SCROPHULARIACEÆ

Genus TORENIA Linnæus

TORENIA CORDIFOLIA Roxburgh.

Torenia cordifolia ROXBURGH, Pl. Corom. 2 (1798) 52, pl. 161; Fl. Ind. 3 (1832) 95; HOOKER in Curtis Bot. Mag. 66 (1840) pl. 3715; HOOKER f., Fl. Brit. Ind. 4 (1885) 276.

LUZON, Tayabas Province, Mount Alzapan, *Bur. Sci. 45676 Ramos and Edaño*, June 6, 1925, in damp open places, altitude about 1,000 meters. India, Java, China.

A species not previously reported from the Philippines. A specimen was sent to Dr. W. A. Hill at Kew for comparison, and he reports:

> We have examined the specimen of *Torenia* that you sent us from the Philippines and have not been able to match it precisely with my Chinese species, or with any material from Siam or Malaya in our Herbarium. It approaches *T. cordifolia* Roxb., but I hesitate to identify it with this species from a single specimen.

We have examined all the specimens of this collection, and although we have found slight differences between them and the description and the figure of *Torenia cordifolia* still we hesitate to separate it from Roxburgh's species.

ACANTHACEÆ

Genus HALLIERACANTHA Stapf

HALLIERACANTHA RAMOSII sp. nov.

Herba erecta, ramosa, circiter 1 m alta, partibus junioribus leviter pubescentibus; foliis in paribus subaequalibus, ovato-lanceolatis, acuminatis, basi acutis, utrinque glabris, 7.5 ad 13 cm longis, 2.5 ad 4.5 cm latis, nervis utrinque 6 ad 7, perspicuis, subtus cystolithis paucis instructis; petiolo usque ad 1.3 cm longo; cymis brevissime pedunculatis, paucifloris; bracteis obovato-lanceolatis, 4 ad 6 mm longis; calycis segmentis anguste lanceolatis, subulatis, 7 ad 9.2 mm longis; corolla alba, extus glabra, tubo ampliato, 5 ad 5.5 mm longo, segmentis subaequilongis, superioribus 2-lobatis, inferioribus 3-lobatis; staminibus 2, aequalibus, antheris ellipsoideis, circiter 1 mm longis, filamentis circiter 4 mm longis, tenuibus; capsulis oblanceolatis, glabris, attenuatis, usque ad 9 mm longis.

An erect branched herb about 1 m high, the younger parts sparingly pubescent with short hairs; the branches minutely canaliculate, glabrous or nearly so, usually dark green when dry, the branchlets very slightly pubescent, angular. Leaves of each pair equal or near the tips of the branchlets more or less unequal, ovate-lanceolate, slenderly acuminate, base acute, membranaceous, dark green above, somewhat paler beneath, shining, 7.5 to 13 cm long, 2.5 to 4.5 cm wide, glabrous on both surfaces, with scattered cystoliths on the lower surface only, the margins entire or very obscurely undulate; lateral nerves 6 or 7 on each side of the midrib, prominent; petioles slender, obscurely pubescent, 4 to 13 mm long. Cymes axillary, very shortly peduncled, few-flowered, the peduncles obscurely pubescent, up to 3 mm in length. Bracts obovate-lanceolate, acute to obtuse, slightly pubescent, 4 to 6 mm long. Flowers sessile or subsessile, the pedicels at most 1 mm long. Calyx segments 5, narrowly lanceolate, subulate, 7 to 9.2 mm long, 0.75 to 1 mm wide, obscurely pubescent. Corolla white, glabrous outside, ciliate at the throat inside, 10 to 10.5 mm long, the tube 5 to 5.5 mm long, cylindric and narrowed at the base, then

somewhat inflated, the larger and lower lip 4.5 mm long, about 3.5 mm wide, 3-lobulate, the lobules 1.5 to 2 mm long, oblong-ovate, the central one larger, the upper lip erect, 2-lobulate, the lobules oblong-ovate, 0.5 to 0.75 mm long. Stamens 2, of the same length; the anthers equal, ellipsoid, about 1 mm long, one cell attached slightly above the other; filaments glabrous except the ciliate base, somewhat flattened, about 4 mm long. Pollen oblong-elliptic. Capsules oblanceolate, attenuate, glabrous, 7 to 9 mm long, 2 to 2.5 mm in diameter, the pedicels in fruit up to 1.5 mm long, and the persistent calyx segments up to 11 mm long.

MINDORO, Pinaligpigan, near Puerto Galera, *Bur. Sci. 46352 Ramos*, December 9, 1925, on forested slopes, altitude about 1,000 meters.

A species in the general alliance with *Hallieracantha brevipetiolata* Merrill, from which it is distinguished, among other characters, by the shape of its leaves and bracts, as well as by its very short peduncles and smaller capsules.

RUBIACEÆ

Genus CANTHIUM Lamarck

CANTHIUM OBLONGIFOLIUM sp. nov.

Frutex erectus, inerme, glaber, circiter 4 m altus; ramis ramulisque teretibus, laevis; foliis oblongo-ellipticis, chartaceis, tenuiter acuminatis, 10 ad 15 cm longis, 4.5 ad 7 cm latis, nervis utrinque 5 vel 6, perspicuis, evanescentibus, reticulis laxissimis vel obsoletis; fructibus axillaribus, tenuiter pedicellatis, solitariis, oblongo-obovoideis, 1.5 ad 2 cm longis, in siccitate leviter longitudinaliter sulcatis, pedicellis filiformibus, 1 ad 1.5 cm longis.

A glabrous, erect, unarmed shrub about 4 m high, the branches and branchlets terete, slender, smooth, pale brown. Leaves oblong-elliptic, chartaceous, 10 to 15 cm long, 4.5 to 7 cm wide, apex slenderly and sharply acuminate, base somewhat decurrent-acuminate, the upper surface smooth and shining, olivaceous-brown when dry, the lower surface paler; lateral nerves 5 or 6 on each side of the midrib, prominent, distant, curved, scarcely or very faintly anastomosing, usually evanescent before reaching the margins, the reticulations very lax, often obsolete; petioles 6 to 10 mm long; stipules triangular, slenderly acuminate, 3 to 4 mm long. Fruits axillary, solitary, long-pedicelled, oblong-

obovoid, yellow when fresh, dark reddish brown when dry, apex rounded, narrowed toward the base, when dry 1.5 to 2 cm long, the pedicels slender, 1 to 1.5 cm long.

PANAY, Capiz Province, Ilaman-ay, *Bur. Sci. 46109 Ramos and Edaño,* October 13, 1925, on forested slopes at low altitudes.

A species apparently allied to *Canthium paucinervium* Merrill, differing in its larger, solitary, oblong-obovoid, long-pedicelled fruits.

CANTHIUM TRICHOPHORUM sp. nov.

Frutex inerme, erectus, perspicue disperse ciliatus; foliis ellipticis, chartaceis, tenuiter acuminatis, basi acutis, 8 ad 16.5 cm longis, 3.5 ad 7.2 cm latis, utrinque disperse ciliatis, nervis utrinque 5 vel 6, perspicuis; fructibus axillaribus, pedicellatis, solitariis, obovoideis, disperse ciliatis, apice truncatis, basi attenuatis, 1.5 ad 2 cm longis, pedicellis villosis, tenuis, 10 ad 15 mm longis, bibracteatis.

An erect, unarmed, prominently ciliate shrub, the branches and branchlets brownish to yellowish brown, slender, terete, ciliate, the branchlets about 2 mm in diameter. Leaves chartaceous, elliptic, 8 to 16.5 cm long, 3.5 to 7.2 cm wide, slenderly and sharply acuminate, base acute, ciliate on both surfaces with long scattered hairs, the upper surface dark brown, shining, the lower surface paler; lateral nerves 5 or 6 on each side of the midrib, very prominent, faintly anastomosing, curved, the reticulations obsolete; petioles densely ciliate, 5 to 9 mm long; stipules ciliate, subulate, 10 to 12 mm long. Fruits axillary, solitary, long-pedicelled, ciliate, obovoid, 1.5 to 2 cm long, longitudinally sulcate, apex rounded-truncate, narrowed to the subacute base, the pedicels slender, 10 to 15 mm long, ciliate, each with a pair of ciliate, narrowly ovate, 2 to 3 mm long bracts.

LUZON, Isabela Province, San Mariano (Ambulawan), *Bur. Sci. 46759 Ramos and Edaño* (type), March 16, 1926, along forested streams, altitude about 400 meters; Mount Moises, *Bur. Sci. 47286 Ramos and Edaño,* March 4, 1926, along forested streams, altitude about 900 meters, *Clemens 17003, 17003a,* April, 1926.

A characteristic species, distinguished by its ciliate, terete branches and branchlets, its elliptic, ciliate, slenderly and sharply acuminate leaves, and its long-pedicelled, ciliate, solitary, obovoid, sulcate fruits. Its alliance is perhaps with *Canthium ellipticum* Merrill.

Genus HEDYOTIS Linnæus

HEDYOTIS CARDIOPHYLLA sp. nov. § Diplophragma.

Frutex scandens; ramulis glabris, teretibus, leavis circiter 3 mm diametro, junioribus obscure angulatis; foliis chartaceis, glabris, fragilis, ovatis, longe tenuiter acuminatis, basi late rotundato-cordatis, 5 ad 8 cm longis, 2 ad 3.8 cm latis, nervis utrinque 4 vel 5, tenuibus vel admodum obscuris vel subobsoletis, haud reticulatis, breviter petiolatis; stipulis haud laciniatis, cuspidatis, apiculis 1 ad 2 mm longis; cymis axillaribus, 0.9 ad 2 cm longis, paucifloris, breviter pedunculatis; calycis tubo ovoideo, 1 ad 1.5 mm longo, lobis 4 oblongo-ovatis, 1.5 ad 2 mm longis; corolla parva, alba, circiter 2.75 mm longa, lobis 4, oblongo-ovatis, circiter 1.75 mm longis; fructibus oblongo-obovoideis, 3 ad 3.5 mm longis.

A slender scandent shrub, the branches greatly elongated, pale, glabrous, terete, smooth, about 3 mm in diameter, the younger parts much slenderer, slightly but sharply angled. Leaves chartaceous, glabrous, rather pale and brittle when dry, ovate, long and slenderly acuminate, base broadly rounded-cordate, 5 to 8 cm long, 2 to 3.8 cm wide; lateral nerves 4 or 5 on each side of the midrib, slender, sometimes obscure or obsolete beneath, slightly impressed on the upper surface, anastomosing, reticulations obsolete; petioles glabrous, 2 to 4 mm long; stipules entire, minute, broader than long, ovate, cuspidate, 2 to 3 mm long, the apiculum 1 to 2 mm long. Cymes axillary, short, 0.9 to 2 cm long, few-flowered, the peduncles slender, 2 to 6 mm long. Flowers mostly in threes, their pedicels very slender, 2 to 7 mm long; bracts ovate-lanceolate, acute, up to 6 mm long; calyx tube ovoid, 1 to 1.5 mm long, the lobes 4, oblong-ovate, 1.5 to 2 mm long; corolla small, white, about 2.75 mm long, the lobes 4, oblong-ovate, about 1.75 mm long. Capsules glabrous, crustaceous, oblong-obovoid, 3 to 3.75 mm long, the apex not protruding above the calyx teeth; the pedicels 3 to 5 mm long; persistent calyx teeth spinulose on the margin, ovate-lanceolate, about 2 mm long; seeds black, compressed, plano-convex, verruculose, about 1 mm long.

LUZON, Nueva Vizcaya Province, Mount Alzapan, *Bur. Sci. 45585 Ramos and Edaño*, May 22, 1925, on forested slopes, altitude about 1,700 meters.

A species well characterized by its elongated slender branches; its ovate, broadly rounded-cordate, long-acuminate, chartaceous,

obscurely nerved, glabrous leaves; and its few-flowered, short, axillary inflorescences.

HEDYOTIS EDANOII sp. nov. § Euhedyotis.

Suffrutex erectus, simplex, circiter 1 m altus, inflorescentiis exceptis glaber; foliis subcoriaceis, lanceolatis, apice longe anguste acuminatis, basi acutis, 11 ad 17.5 cm longis, 1.5 ad 3.2 cm latis, utrinque nitidis, nervis utrinque 5 vel 6, adscendentibus, haud distinctis; stipulis pectinato-laciniatis, 1 ad 1.4 cm longis, segmentis 5 ad 7, subulatis, 3 ad 7 mm longis; inflorescentiis axillaribus, globosis, densis, sessilibus, 1 ad 1.8 cm diametro; floribus numerosis, confertis, sessilibus vel subsessilibus, 6 ad 7 mm longis; bracteolis linearis ad subspatulatis, margine ciliato-hirsutis, 4.5 ad 6.25 mm longis; calycis tubo campanulato, glabro, 2 ad 3 mm longo, lobis 4, plerumque subspatulatis, subacutis, margine et intus ciliato-hirsutis, 3.25 ad 4 mm longis.

An erect unbranched shrub, about 1 m high, glabrous throughout except the somewhat ciliate-hirsute inflorescences, the upper parts of the stem sulcate and angled. Leaves subcoriaceous, lanceolate, apex slenderly long-acuminate, base acute, 11 to 17.5 cm long, 1.5 to 3.2 cm wide, dark brown when dry, the midrib distinct, the lateral nerves 5 or 6 on each side of the midrib, faint, ascending, smooth and shining on both surfaces; petioles 0.5 to 1.8 cm long; stipules 1.2 to 1.4 cm long, glabrous, laciniate-pectinate, the laciniæ subulate, 3 to 7 mm long, the inner ones longer. Inflorescence axillary, dense, globose, sessile, 1 to 1.8 cm in diameter. Flowers numerous, sessile or subsessile, crowded, 6 to 7 mm long; bracteoles subtending each flower 4.5 to 6.25 mm long, 1.75 to 2.1 mm wide, linear to subspatulate, subacute, the margins and inside ciliate-hirsute, outside glabrous; calyx tube campanulate, glabrous, 2 to 3 mm long, the lobes 4, usually subspatulate, but sometimes linear, subacute, margins and inside ciliate-hirsute, 3.25 to 4 mm long.

LUZON, Isabela Province, Mount Moises, *Bur. Sci. 47327 Ramos and Edaño*, March 1, 1926, on forested slopes near the summit, altitude about 1,250 meters; *Clemens 17006, 17007*, April 16 to 23, 1926.

The alliance of this species is manifestly with *Hedyotis rigida* (Blume) Miquel, from which it is distinguished by its habit, its larger and laciniate-pectinate stipules, its larger inflorescences, and its nearly nerveless leaves. It is distinguished from *Hedyotis simplex* Merrill by its young stems being glabrous, its

leaves with very faint nerves, its stipule characters, and its larger bracteoles.

Genus IXORA Linnæus

IXORA TENELLIFLORA Merrill.

Ixora tenelliflora MERRILL in Philip. Journ. Sci. **29** (1926) 423.

PALAWAN, Buena Vista near Puerto Princesa, *For. Bur. 30089 Cenabre*, September 21, 1925. A tree about 5 m high in forests, with white odorless flowers.

The specimen agrees perfectly with the type, *Castro and Melegrito 1384*, August 1, 1923, from Banguey Island, British North Borneo. The species is new to the Philippines.

Genus MORINDA Linnæus

MORINDA ELLIPTIFOLIA sp. nov.

Frutex scandens, infructescentiis exceptis glaber, ramulis 2 ad 3.5 mm diametro; foliis subcoriaceis, oblongo-ellipticis ad ellipticis, 10.5 ad 16 cm longis, 4.8 ad 8.7 cm latis, apice acute acuminatis, basi late acutis, nervis utrinque circiter 9, distinctis, distantibus; fructibus solitariis vel binis, globosis, minute puberulis, 1.5 ad 2 cm diametro, pedicellis dense minute puberulis, tenuibus, 3 ad 4 cm longis.

A woody vine, glabrous except the infructescences, the branches pale brown and rugose when dry, the ultimate branchlets subterete, 2 to 3.5 mm in diameter. Leaves subcoriaceous, oblong-elliptic to elliptic, 10.5 to 16 cm long, 4.8 to 8.7 cm wide, olivaceous-brown to dark brown and slightly shining when dry, acutely acuminate, the base broadly acute, rarely subrounded; lateral nerves about 9 on each side of the midrib, slender, distant, distinct as are the primary reticulations; petioles black, 10 to 20 mm long; stipules somewhat sheathing, deciduous, 3 to 4 mm long. Fruits terminal, the heads solitary or in pairs, globose, minutely puberulent, 1.5 to 2 cm in diameter, green when fresh, black when dry, their peduncles densely minutely puberulent, rather slender, 3 to 4 cm long, 1 to 1.25 mm in diameter.

MINDANAO, Davao Province, Galintan, *Bur. Sci. 48909 Ramos and Edaño*, June 4, 1927, on forested slopes, altitude about 250 meters.

A species belonging in the group with *Morinda coriacea* Merrill, differing by its subcoriaceous, oblong-elliptic to elliptic leaves, longer petioles, minutely puberulent fruits, and its longer, minutely puberulent peduncles.

Genus NEONAUCLEA Merrill

NEONAUCLEA AURICULATA sp. nov.

Arbor parva, distincte pubescentibus; foliis subcoriaceis, lanceolatis ad oblongo-lanceolatis, usque ad 19 cm longis, 4.5 cm latis, sursum angustatis, apice obtusis, basi rotundato-cordatis, lobis subauriculatis, nervis utrinque 16 ad 18, perspicuis; capitulis terminalibus, solitariis ad ternatis, longe pedunculatis, subanthesin 3.5 ad 4.5 cm diametro; floribus ebracteolatis; calycis lobis minute puberulis, circiter 4 mm longis; corollae tubo 7 ad 9 mm longo, glabro vel subglabro.

A tree about 6 m high, the branchlets, petioles, stipules, peduncles, and leaves pubescent. Branches terete, brown, glabrescent. Leaves subcoriaceous, lanceolate to oblong-lanceolate, 10.5 to 19 cm long, 2.5 to 4.5 cm wide, narrowed to the obtuse apex, the base rounded-cordate, the lobes subauriculate, the upper surface brown, shining, sparingly pubescent, the lower surface paler, and more densely pubescent; lateral nerves 16 to 18 on each side of the midrib, prominent, the reticulations distinct; petioles 2 to 7 mm long; stipules oblong-ovate, rounded, about 2 cm long, 0.8 to 0.9 cm wide. Peduncles terminal, 4 to 6 cm long, solitary, in pairs, or in threes, somewhat pubescent. Heads in flower 3.5 to 4.5 cm in diameter, the flowers ebracteolate. Calyx tube minutely and densely puberulent, about 1.5 mm long, the persistent free lobes about 4 mm long. Corolla tube narrowly funnel-shaped, glabrous or minutely puberulent outside, 7 to 9 mm long, pale yellow when fresh, reddish brown when dry, the lobes 5, oblong-ovate, obtuse, about 1.5 mm long. Anthers about 1.25 mm long. Style exserted, up to 1.6 cm long.

MINDANAO, Davao Province, Mati, *Bur. Sci. 49281 Ramos and Edaño*, April 27, 1927, in thickets and second-growth forests at low altitudes.

A species belonging in the group with *Neonauclea angustifolia* (Haviland) Merrill, and well characterized by its pubescent, auriculate-cordate, lanceolate to oblong-lanceolate leaves.

Genus PSYCHOTRIA Linnæus

PSYCHOTRIA CARINATA sp. nov. § Grumilea.

Frutex erectus, infructescentiis et subtus foliis ad costa nervisque plus minusve castaneo-ciliatis, ramulis teretibus, laevis, glabris; foliis chartaceis, obovatis ad oblongo-ellipticis, breviter late acuminatis, basi acutis, 9 ad 17 cm longis, 4 ad 8 cm latis, supra nitidis, nervis utrinque 11 ad 13, perspicuis; infructes-

centiis brevibus, circiter 2 cm longis, breviter pedunculatis; fructibus paucis, confertis, glabris, obovoideis, sessilibus, perspicue 8-carinatis, 8 ad 10 mm longis; seminibus plano-convexis, perspicue carinatis, albumine ruminato.

An erect shrub, the branches and branchlets terete, smooth, glabrous, infructescences and leaves on the lower surface along the midrib and nerves more or less castaneous-ciliate. Leaves chartaceous, obovate, to oblong-elliptic, broadly and abruptly acuminate, base acute, 9 to 17 cm long, 4 to 8 cm wide, somewhat reddish brown when dry, the upper surface glabrous, shining; lateral nerves 11 to 13 on each side of the midrib, prominent, slightly curved, anastomosing, the reticulations slender; younger petioles castaneous-ciliate, soon becoming glabrous, 1 to 2.5 cm long; stipules glabrescent, lanceolate, about 2 cm long, 4.5 to 6 mm wide. Infructescences 1.8 to 2.5 cm long, including the short peduncles; the fruits few, crowded, red when mature, black when dry, glabrous, smooth, sessile, obovoid, apex rounded to truncate, base somewhat narrowed, prominently 8-ridged, 8 to 10 mm long; seeds obtuse at both ends, with 3 prominent ridges on the back, the albumen ruminate.

LUZON, Tayabas Province, Casiguran, *Bur. Sci. 45278* (type) *45518 Ramos and Edaño*, May and June, 1925, in damp forests along Kabulig and Mamatoc Rivers at low altitudes.

A species apparently belonging in the same group with *Psychotria rizalensis* Merrill, well characterized by its few, sessile, crowded, obovoid, prominently 8-ridged fruits and the obovate to oblong-elliptic leaves which are abruptly and broadly acuminate.

PSYCHOTRIA LONGISSIMA sp. nov. § Grumilea.

Frutex erectus, inflorescentiis minutissime puberulis exceptis glaber; ramis teretibus, junioribus leviter compressis; foliis lanceolatis sursum angustatis, acutis ad obtusis, basi cuneatis, coriaceis, 16 ad 26 cm longis, 3.5 ad 6.4 cm latis, utrinque nitidis, nervis utrinque 20 ad 24, valde perspicuis, arcuato-anastomosantibus, reticulis distinctis; petiolo 4 ad 7 cm longo; paniculis 6 ad 8 cm longis, e basi ramosis vel brevissime pedunculatis, minute puberulis; floribus 7.5 ad 9 mm longis, brevissime (1 ad 2 mm) pedicellatis; calycibus minute puberulis, 5 ad 5.5 mm longis; corollae tubo cylindrico, intus dense villoso, 3.5 ad 4 mm longo, lobis oblongo-ovatis, acutis, 2.75 ad 3.25 mm longis; fructibus breviter pedicellatis, obovoideis, 7 ad 8 mm longis, 8-carinatis; seminibus plano-convexis, albumine ruminato.

An erect shrub, glabrous throughout except the minutely puberulent inflorescences, branchlets dark brown, somewhat compressed, 4 to 7 mm in diameter. Leaves coriaceous, lanceolate, narrowed upward to the acute or obtuse apex, base cuneate, 16 to 26 cm long, 3.5 to 6.4 cm wide, the upper surface olivaceous-brown, smooth and shining, the lower surface a little paler than the upper, somewhat shining; lateral nerves 20 to 24 on each side of the midrib, very prominent, prominently arched-anastomosing, the reticulations distinct on both surfaces; petioles 4 to 7 cm long. Panicles sessile or subsessile, 6 to 8 cm long, with one longer central branch and two shorter lateral basal ones, few-flowered, minutely puberulent. Flowers white, shortly pedicellate, 7.5 to 9 mm long, their pedicels minutely puberulent, 1 to 2 mm long; calyx minutely puberulent, 5 to 5.5 mm long, 3 to 4 mm in diameter, the teeth minute; corolla tube cylindric, densely villose within, 3.5 to 4 mm long, the lobes oblong-ovate, acute, 2.75 to 3.25 mm long. Fruits shortly pedicellate, brown to dark brown when dry, obovoid, apex rounded to truncate, base narrowed, 7 to 8 mm long, with 8 or 9 ridges or keels. Seeds plano-convex, albumen ruminate.

LUZON, Tayabas Province, Mount Alzapan, *Bur. Sci. 45681 Ramos and Edaño*, June 7, 1925, rare on forested slopes, altitude about 1,300 meters.

A distinct species, strongly characterized by its very prominently nerved, elongated, lanceolate, coriaceous, long-petioled leaves, and the minutely puberulent inflorescences.

Genus VILLARIA Rolfe

VILLARIA FASCICULIFLORA sp. nov.

Frutex circiter 2 m altus, floribus exceptis glaber; ramis ramulisque teretibus, laevis; foliis coriaceis, oblongo-ellipticis, perspicue acuminatis, basi acutis, 16 ad 23 cm longis, 5 ad 7 cm latis, nervis utrinque 12 ad 13, perspicuis, distantibus; petiolo 0.8 ad 1 cm longo; stipulis coriaceis, glabris, oblongo-ovatis, obtusis, 1.5 ad 1.8 cm longis; cymis fasciculiformis, brevissime (1.5 ad 3 mm) pedunculatis, axillaribus, floribus confertis, usque ad 11 mm longis, subsessilibus; pedicellis usque ad 1.5 mm longis; calycis tubo cupuliforme, usque 1.5 mm longo extus glabro, intus ciliato-piloso, lobis 5, late ovatis, rotundatis, 1.5 ad 2 mm longis, corolla alba, usque ad 1 cm longa, tubo subcylindraceo, usque ad 5 mm longo, extus glabro, intus pubescente, lobis 5, erectis, subrotundatis, circiter 3.5 mm longis.

A shrub about 2 m high, glabrous throughout except the flowers; the branches and branchlets terete, smooth, dark brown, the former 4 to 5 mm in diameter. Leaves coriaceous, oblong-elliptic, prominently acuminate, base acute, 16 to 23.5 cm long, 5 to 7 cm wide, pale brown above, reddish brown beneath, somewhat shining on both surfaces; lateral nerves 12 to 13 on each side of the midrib, distant, prominent, becoming faint toward the margins, much darker than the blade, anatomosing, the reticulations somewhat obscure; petiole rather short, 8 to 10 mm long; stipules coriaceous, glabrous, shining, 15 to 18 mm long, 5 to 8 mm wide, oblong-ovate, obtuse. Cymes fasciculiform, very shortly (1.5 to 3 mm) peduncled, axillary. Flowers crowded, 10 to 11 mm long, subsessile, the bracteoles 2, ovate, acute, 3 to 3.5 mm long, glabrous outside, ciliate-pilose inside and on the margins. Calyx tube cup-shaped, glabrous outside, ciliate-pilose inside, 1 to 1.5 mm long, 3 to 4 mm in diameter; lobes 5, broadly ovate, rounded, 1.5 to 2 mm long, 2.75 to 3 mm wide, glabrous outside, ciliate-pilose inside and on the margins. Corolla white, 8.7 to 10 mm long, the tube subcylindric, 4.7 to 5 mm long, 4 to 4.5 mm in diameter, glabrous outside, ciliate-pilose inside especially at the throat; the lobes 5, erect, subrounded, glabrous on both surfaces, the margins ciliate, 3 to 3.5 mm long. Anthers 5, sessile, linear, about 4 mm long. Ovary 1-celled. Style somewhat flattened, glabrous, about 2 mm long. Stigma oblong, densely pilose, about 5 mm long, 2 mm in diameter.

LUZON, Isabela Province, San Mariano (Debuluan), *Bur. Sci. 46775 Ramos and Edaño*, March 25, 1926, along forested streams, altitude about 700 meters.

A very striking species not closely allied to any of the known Philippine forms. It is well characterized by its fasciclelike, very shortly peduncled cymes, and subsessile flowers. It resembles *Hypobathrum*, but apparently does not belong to that genus.

Genus WILLIAMSIA Merrill

WILLIAMSIA PUBESCENS sp. nov.

Frutex dioicus, circiter 1 m altus, ramis teretibus, perspicue pubescentibus; foliis membranaceis, 8 ad 15 cm longis, 1.4 ad 3.5 cm latis, oblongis ad oblongo-lanceolatis, tenuiter attenuato-acuminatis, basi acutis, utrinque ciliato-pubescentibus, nervis utrinque 10 ad 12, perspicuis curvato-adcendentibus, reticulis subobscuris; floribus axillaribus, solitariis, sessilibus vel brevissime pedicellatis; involucris superioribus inaequaliter profunde

4-lobatis, lobis minoribus subulatis, circiter 6 mm longis, 0.75 mm latis, majoribus ovato-lanceolatis, 5 ad 6 mm longis, circiter 3.5 mm latis, apice bilobulatis, lobis majoribus involucris inferioribus anguste lanceolatis, attenuatis, circiter 5 mm longis, minoribus ovatis, acutis, circiter 3.5 mm longis, 2 mm latis; calycibus membranaceis, dense ciliato-villosis, 3 ad 3.5 mm diametro, lobis 4, anguste lanceolatis, attenuatis, usque ad 10 mm longis, 2 mm latis, dense ciliato-villosis; corolla coriacea, 6-lobata, rigida, tubo circiter 1.5 mm longo, leviter pubescente, lobis ovatis, acutis, circiter 1 mm longis; fructibus globosis, dense ciliatis, circiter 10 mm diametro, 6-locellatis, breviter pedicellatis, pedicellis usque ad 2 mm longis.

A diœcious shrub about 1 m high, conspicuously ciliate-pubescent except the glabrous older branches, the branches terete, pale, the branchlets 1.5 to 3 mm in diameter. Leaves membranaceous, 8 to 15.2 cm long, 1.4 to 3.5 cm wide, oblong to oblong-lanceolate, slenderly attenuate-acuminate, base acute, densely ciliate-pubescent on both surfaces; lateral nerves 10 to 12 on each side of the midrib, prominent on the lower surface, curved-ascending, the reticulations somewhat obscure; petioles densely pubescent, 0.5 to 1 cm long; stipules narrowly lanceolate, attenuate, membranaceous, densely pubescent outside, glabrous inside, 2 to 2.8 cm long, 2.5 to 5 mm wide. Flowers axillary, solitary, sessile or very shortly pedicellate; involucres densely ciliate-pubescent, the upper inner one unequally and deeply 4-lobed, the outer lobes subulate, about 6 mm long, 0.75 mm wide, the inner and larger ones ovate-lanceolate, 5 to 6 mm long, about 3.5 mm wide, the apex usually bilobulate, the lobules acute, up to 1.5 mm long, the outer involucre smaller and subequally deeply 4-lobed, the outer lobes narrowly lanceolate, attenuate, about 5 mm long, 1 mm wide, the inner lobes entire, acute about 3.5 mm long, 2 mm wide. Calyx membranaceous, the tube cup-shaped, densely ciliate-villose, about 3 mm long, 3 to 3.5 mm in diameter; the lobes 4, long, densely ciliate-villose, narrowly lanceolate, attenuate, subequal, 9 to 10 mm long, 1.5 to 2 mm wide. Corolla thickly coriaceous, firm, the tube about 1.5 mm long, somewhat pubescent, the lobes 6, ovate, acute, about 1 mm long, densely pubescent particularly at the apex. Fruits shortly pedicellate, globose, densely ciliate, about 10 mm in diameter, 6-celled, crowned by the persistent calyx lobes. In fruit the persistent upper involucre is up to 10 mm long, and the much smaller, lower involucre is up to 5 mm in length.

LUZON, Isabela Province, Mount Moises, *Bur. Sci. 47275 Ramos and Edaño,* March 3, 1926; *Clemens 16852,* April 16 to 23, 1926 (description of the flowers was based on this specimen), *Clemens 17000,* April, 1926, on forested slopes, altitude about 1,200 meters.

A species well characterized by being conspicuously ciliate-pubescent throughout, except the older branches, and particularly by the long, persistent, subulate, calyx lobes, and the long-lobed involucres.

WILLIAMSIA TRIFLORA sp. nov.

Frutex circiter 1 m altus; foliis oblongis, 11 ad 16.5 cm longis, 2.3 ad 6 cm latis, acute acuminatis, basi acutis, sparse ciliatis; petiolo 8 ad 15 mm longo; inflorescentiis breviter pedunculatis, 3-floris, pedunculis tenuibus, 3.5 ad 5 mm longis; floribus breviter pedicellatis; calycis tubo cupulato, circiter 2 mm longo, 4 mm diametro, lobis 4, membranaceis, utrinque ciliatis, inaequalibus, oblongo-ovatis vel anguste oblongo-ovatis, 6 ad 8.5 mm longis, 1.75 ad 4 mm latis; corolla alba, coriacea, rigida, apice ciliata excepta glabra, tubo usque ad 1.75 mm longo, lobis oblongo-ovatis, acutis, usque ad 4.5 mm longis, 2 mm latis; ovario 6- vel 7-loculare, globoso; staminibus 6 vel 7, filamentis filiformibus glabris, antheris oblongis, 1 ad 1.25 mm longis.

A shrub about 1 m high, ciliate-pubescent all over except the glabrous older branches, the branches terete, pale. Leaves oblong, acutely acuminate, base acute, 11 to 16.5 cm long, 2.3 to 6 cm wide, sparsely ciliate on both surfaces; lateral nerves 13 or 14 on each side of the midrib, very prominent; petioles 8 to 15 mm long; stipules submembranaceous, lanceolate, 22 to 28 mm long, 5 to 7 mm wide. Inflorescence shortly peduncled, 3-flowered; the peduncles slender, 3.5 to 5 mm long; upper involucre unequally 4-lobed, outer lobes narrowly linear-lanceolate, 6 to 7 mm long, about 1 mm wide, the larger and inner lobes oblong-ovate, subacute, 7 to 8 mm long, 3 to 3.5 mm wide, the basal involucre much smaller, subequally 4-lobed, the outer lobes subulate, 5 to 5.5 mm long, 0.5 to 0.75 mm wide, the inner and smaller lobes narrowly lanceolate, 3.5 to 4 mm long, 1.5 to 2 mm wide. Flowers pedicellate, the pedicels about 3 mm long. Calyx tube cup-shaped, about 2 mm long, 4 mm in diameter, the lobes 4, membranaceous, ciliate on both surfaces, unequal, oblong-ovate or narrowly oblong-ovate, 6 to 8.5 mm long, 1.75 to 4 mm wide. Corolla white, thickly coriaceous, firm, glabrous except the apex ciliate, the tube 0.5 to 1.75 mm long, the

lobes oblong-ovate, acute, 2.5 to 4.5 mm long, 1.5 to 2 mm wide. Ovary 6- or 7-celled, globose, about 1.75 mm in diameter. Style short, up to 0.5 mm in length. Stamens 6 or 7, the filaments short, filiform, glabrous, the anthers oblong, 1 to 1.25 mm in length.

LUZON, Tayabas Province, Casiguran, *Bur. Sci. 45458 Ramos and Edaño*, May 5, 1925, along forested streams at low altitudes.

In making the preliminary identifications this material was tentatively referred to *Williamsia pubescens*, which in superficial characters the present species closely resembles. It is distinguished from that species by its 3-flowered, slenderly pedicelled, cymose inflorescences. The leaves are somewhat larger, the petioles are relatively longer, and the flowers are structurally different.

CAMPANULACEÆ

Genus PENTAPHRAGMA Wallich

PENTAPHRAGMA PAUCINERVE sp. nov.

Suffrutex erectus, partibus junioribus plus minusve crispato-pubescente; foliis oblongo-ellipticis, leviter subfalcatis, subacutis ad breviter obtuseque acuminatis, basi subinaequilateraliter acutis, margine crenulato-denticulatis, 17 ad 21 cm longis, 9 ad 11 cm latis, nervis utrinque 3 ad 4, adscendentibus, supra glabris, olivaceis, nitidis, subtus crispato-pubescentibus, petiolo 3.5 ad 6.5 cm longo; inflorescentiis paucifloris, haud scorpoideis, breviter pedunculatis, 2.5 ad 3 cm longis; floribus 5-meris, sessilibus, 2.5 ad 3 cm longis; corolla campanulata, lobis oblongo-ovatis, breviter acuminatis, 2 ad 3 mm longis.

A suberect or erect undershrub, apparently unbranched, the younger parts more or less pubescent with crisped hairs. Leaves membranaceous, 17 to 21 cm long, 9 to 11 cm wide, slightly curved, oblong-elliptic, subacute to very shortly and obtusely acuminate, base acute, equilateral or slightly inequilateral, margin crenulate-denticulate, olivaceous green and glabrous above, paler and pubescent with crisped hairs beneath; lateral nerves prominent, 3 or 4 on each side of the midrib, ascending; petioles pubescent, 3.5 to 6.5 cm long. Inflorescences nonscorpoid, sessile or shortly peduncled, 2.5 to 3 cm long, few-flowered. Flowers 3 to 7, white and yellow, sessile, 2.3 to 2.5 cm long; bracts oblong-ovate to oblong, membranaceous, pubescent, 2.3 to 2.7 cm long. Calyx somewhat pubescent, cylindric, 1.5 to 1.8 cm long, 3 to 4 mm in diameter, the lobes 5,

unequal, oblong, obtuse, membranaceous, pubescent, 8 to 11 mm long, 3.5 to 5.25 mm wide. Corolla campanulate, 6 to 8 mm long, the lobes oblong-ovate, shortly acuminate, membranaceous, pubescent outside, 2 to 3 mm long.

LUZON, Nueva Vizcaya Province, Mount Alzapan, *Bur. Sci. 45634 Ramos and Edaño*, May 22, 1925, on forested slopes, altitude about 1,700 meters.

A species manifestly allied to *Pentaphragma philippinense* Merrill, differing by its oblong-elliptic, few-nerved, shortly acuminate leaves and sessile flowers.

ILLUSTRATIONS

PLATE 1

Pandanus nobilis sp. nov.; a syncarp, reduced.

PLATE 2

Panicum ancylotrichum sp. nov.; *1*, habit sketch of the plant, × 0.5; *2*, a branch with the inflorescence; *3*, part of the main stem; *4*, detail of the base of the lamina and a portion of the sheath with the auricles, × 4; *5*, a branch of the panicle, showing a spikelet, × 10; *6*, the first glume, interior view, × 10; *7*, the second glume, interior view, × 10; *8*, the third glume, interior view, × 10; *9*, the flowering glume, × 10.

PLATE 3

Knema cenabrei sp. nov.; *1*, a leaf, × 0.8; *2*, a flower, top view, × 2; *3*, a flower, side view, × 2; *4*, a fascicle of flowers, × 1; *5*, the staminal disk, top view, enlarged; *6*, the staminal disk, lateral view, enlarged.

PLATE 4

Eisocrechiton bracteata g. et sp. nov.; *1*, habit sketch, about × 0.8; *2*, a leaf, showing details of venation, × 0.8; *3*, a stamen, lateral view, ×12; *4*, base of an anther, showing transversely subcordate connective, × 12; *5*, a petal, × 3.2; *6*, calyx and style, × 3.2.

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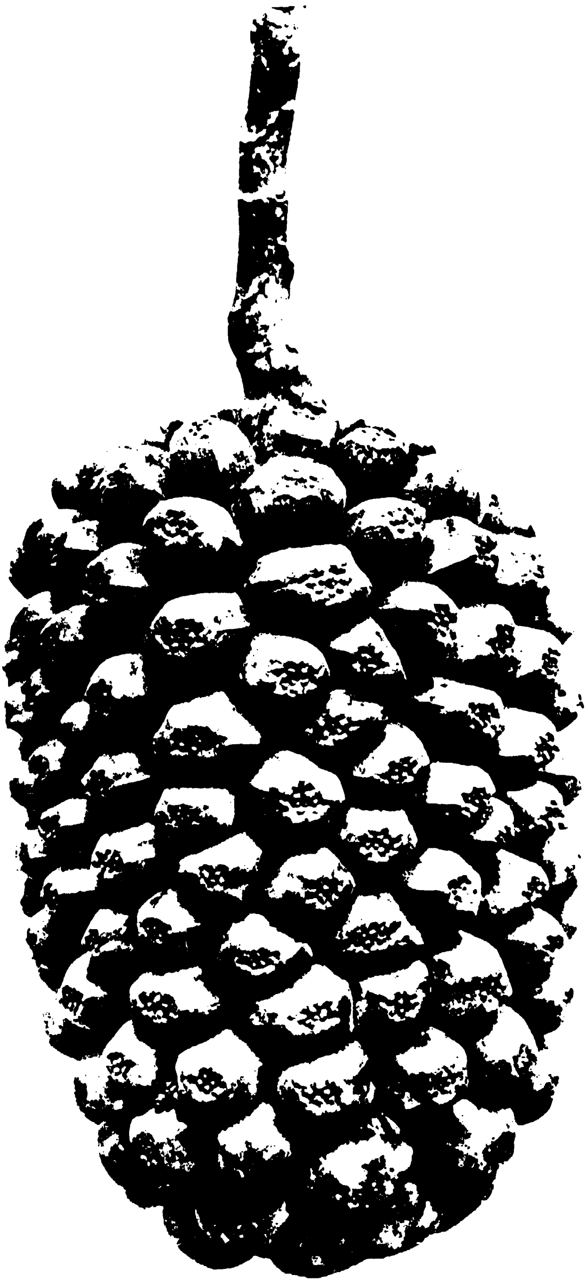

PLATE 1. PANDANUS NOBILIS SP. NOV.

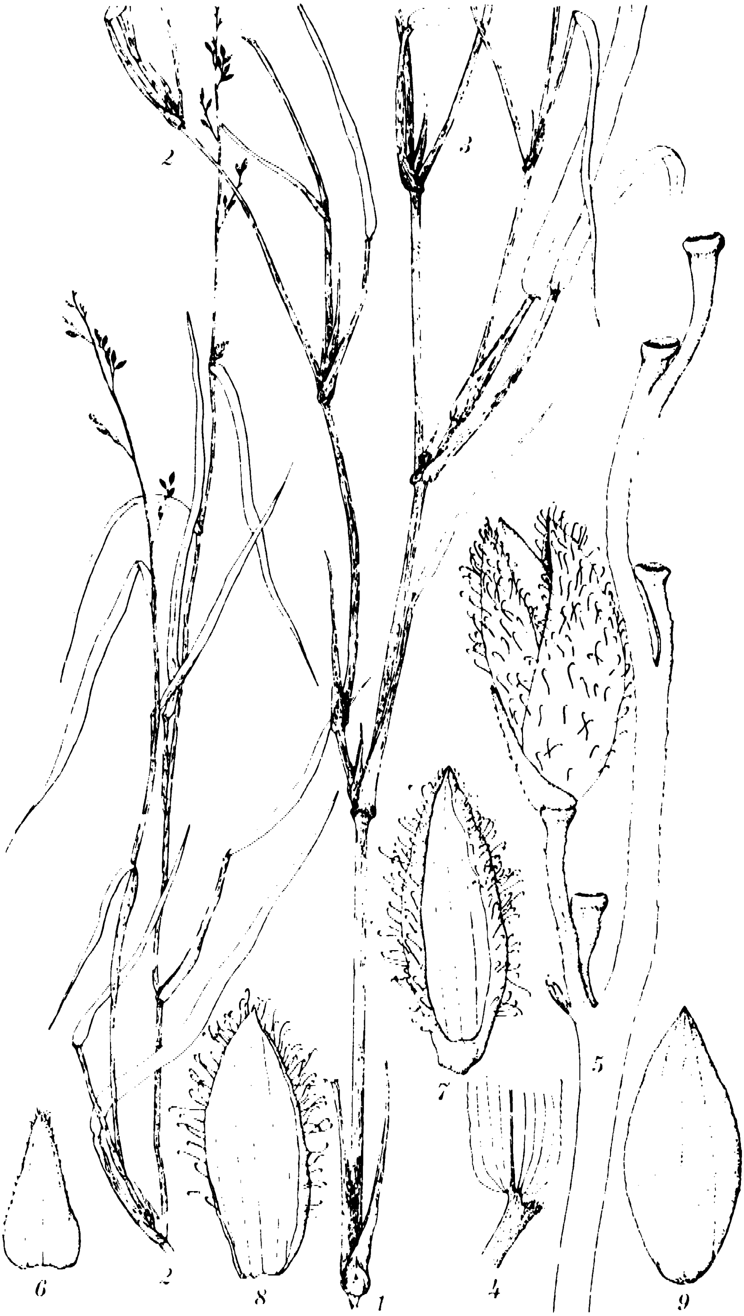

PLATE 2. PANICUM ANCYLOTRICHUM SP. NOV.

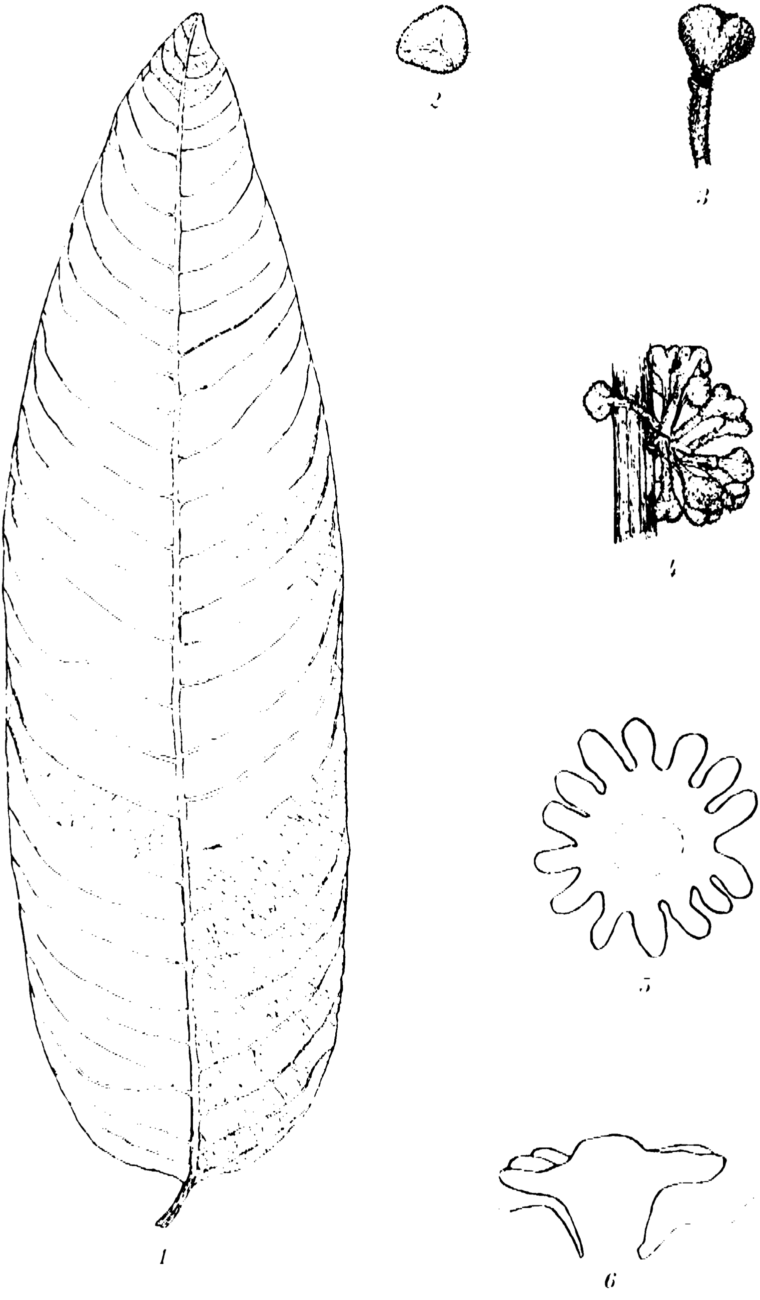

PLATE 3. KNEMA CENABREI SP. NOV.

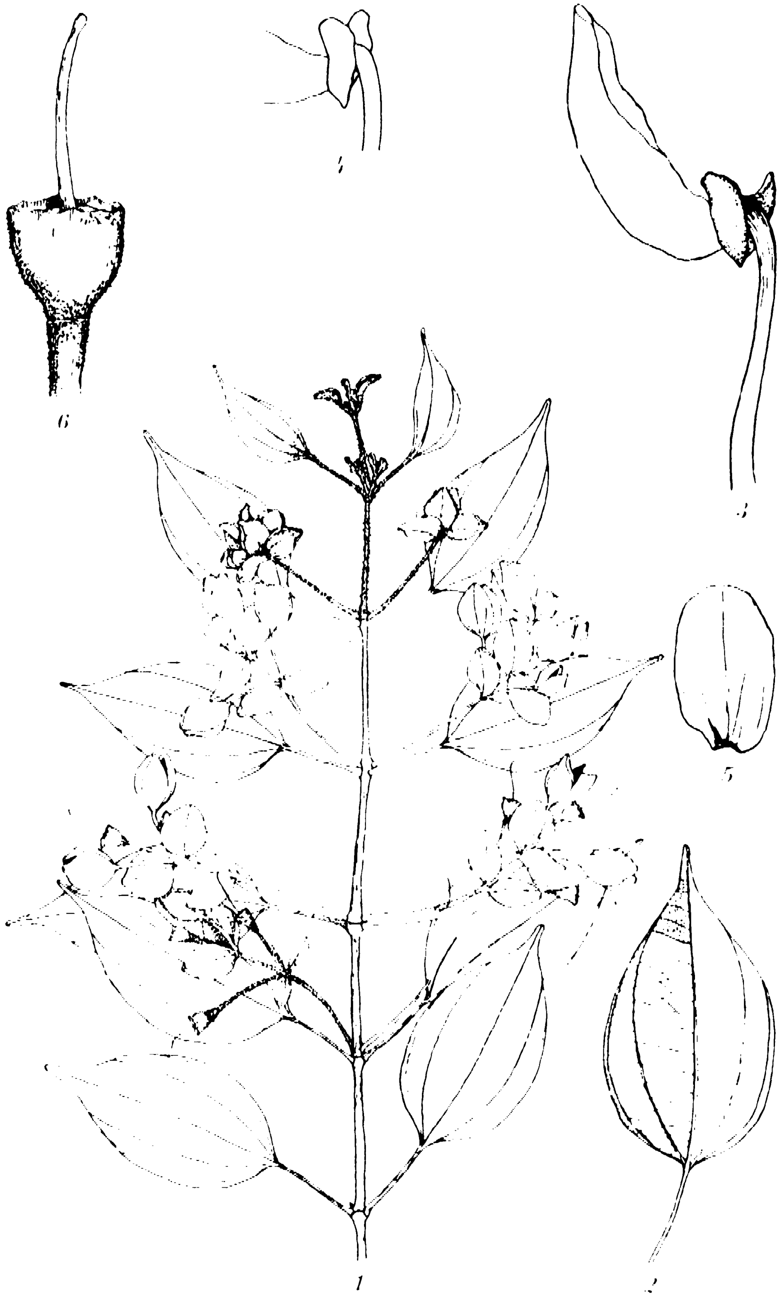

PLATE 4. EISOCRECHITON BRACTEATA G. ET SP. NOV.

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 37 NOVEMBER, 1928 No. 3

A DISCUSSION OF THE ETIOLOGY OF LEPROSY, WITH ESPECIAL REFERENCE TO THE POSSIBILITY OF THE TRANSFERENCE OF LEPROSY BY INSECTS, AND THE EXPERIMENTAL INOCULATION OF THREE MEN

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SIX TEXT FIGURES

INTRODUCTION

Although there can be no manner of doubt that leprosy is an infectious disease and that as such it can only be acquired from an antecedent case, nothing accurate is known concerning the method or methods by which the disease is transferred or of how or where lepra bacilli enter the body.

With regard to the portal of entry for the infection, practically all evidence obtainable indicates that the bacilli probably enter the body through the skin. Infection through the alimentary canal and through the genital organs has always been considered as highly improbable from the nature of the disease and its known epidemiological characteristics. On the other hand, a number of writers have claimed the respiratory tract as the common portal of entry. The lungs may be easily dismissed since they are rarely affected by leprosy and then at a late period of the disease; but nasal lesions are among the commonest lesions of leprosy, and some authors have found lesions and bacilli in the nose to be the most constant single symptom

[1] From the United States Army Medical Department Research Board.

in leprosy. Heiser found it in 799 out of 1,200 lepers. But most of Heiser's lepers were advanced cases. Solis and Wade examined 250 children above 3 years of age who developed leprosy at Culion, and in 60 per cent found lesions in the skin only. They failed to find a case with positive nasal smears in the absence of positive skin lesions. Other authors have reported finding bacilli in the nose rarely in early cases, and Neisser stated that he had never seen a single case of exclusive leprosy of the nose. The frequency of the first observable lesion on the face and the free communication with the lymph channels of the nose may readily account for the occurrence of early nasal infection. Most authorities are of the opinion that while in certain cases the nose may be a portal of entry, this cannot be accepted as the common method of transmission.

This leaves us only the skin as the common portal of entry. In many, perhaps the majority of cases, a sharply localized cutaneous lesion is the first demonstrable lesion of leprosy; and while it must be admitted that in any given case it is impossible to prove that these lesions are the first and only manifestations of leprosy, still this is a strong probability. Many such observations have been made of which the following may be quoted. Cognac and Mougeot(1) found in Cochin China, that of 2,437 cases, the first sign of leprosy appeared 550 times on the feet, 420 times on the hands, 321 times on the hands and feet, and 337 times on the face. Callender and Bitterman(2) in a study of 259 lepers in the Philippines found that the first observed lesion of leprosy occurred on an exposed portion of the body in 95.5 per cent of the cases. The significance of this observation is reduced by the fact that in 78.2 per cent of the cases the first symptom observed was anæsthesia which indicates a nerve involment. Nevertheless, the early involment of the nerves by no means excludes the skin as the portal of entry, since the bacilli so entering may readily gain access to the nerves by blood and lymph channels. Callender and Bitterman conclude that their data on the location of the primary lesion add to similar data reported by others and favor the theory that the organism enters the body through abrasions or similar wounds in the integument of the exposed parts of the body. Rodriguez(3) records a single cutaneous lesion, believed to be the initial lesion in 75 per cent of a series of 59 children who became leprous at Culion. The commonest sites of this initial lesion were the buttocks, 28 per cent; extremities, 34.9 per cent;

and cheeks, 11.8 per cent. From this unusually favorable material it seems probable that in 75 per cent of early cases the first demonstrable lesion is not only found upon the skin, but upon an exposed part of the body.

Admitting the probability that the skin is the most frequent portal of entry, we are confronted with a further difficulty. According to the opinion of most authorities leprosy is contagious; that is, it is conveyed by personal contact with a leper, or by intermediate contact by handling articles contaminated by lepers. Some of the known facts concerning leprosy favor this view; as, for instance, the enormous number of bacilli discharged by advanced lepers from ulcerating lesions of the skin, from the nasal lesions, and in the various secretions and excreta; the fact that leprosy is often a familial disease; that the denser the population, the greater is the tendency to the incidence of the disease in those countries where it is endemic; and finally that from time immemorial popular opinion has always assigned contact as the method of transmission.

While not denying that such contact may be one method of transmission of leprosy, there is nothing in the evidence available to indicate that it is the only method or even the most usual method of transfer. In fact there are some considerations that indicate that transfer by bodily contact must be unusual. Hirch(4) has compiled a great mass of evidence in opposition to the transmission of leprosy by contact, and says:

> I am convinced that there is not a single fact that positively and irrefutably shows the transmission of the disease through contagion; on the other hand there are very cogent facts that contradict such a conception since they are in complete contradiction with all experience concerning the transmission of true contagious diseases.

Such arguments may be summarized as follows:

1. The frequently observed instances in which endemic foci are sharply circumscribed in spite of free and even unhygienic communication with the neighboring people. In the Philippines, for example, we have the relatively high infection rate for Cebu and for Albay and the Bicol provinces in spite of free communication with the surrounding people.

2. Although leprosy is often a familial disease, on the other hand there are many more instances where it has not spread to other members of the family. Even married couples, one of whom was leprous, have lived in intimate relationship as long as ten years without conveying the infection, and between in-

fected husbands and wives usually not more than 5 per cent contract the disease, the single exception being in India, where the percentage is 6.5.

3. McCoy in Hawaii, Gregory in Cape Colony, and the Leprosy Commission in India found that the proportion of healthy persons living with lepers who became infected is 4.2, 4.5, and 5.5 per cent, respectively, in these different countries, while in Japan and Norway the percentage in both was about 2.7. Thus leprosy cannot be considered as a very contagious disease since only about one person out of twenty, living in close contact with a leper, contracts it. This very small percentage of infected, among people taking no precautions, and continuously exposed, indicates that leprosy is far less transmissible than syphilis, tuberculosis, or any other disease that is known to be transmitted by direct or indirect contact.

4. Doctors and nurses in leprosaria, where they come into daily, intimate, personal contact with lepers and with objects contaminated by lepers, never contract the infection. The few doubtful exceptions that are recorded only prove the rule. Leprosy has never been transmitted even in the numerous instances sin which physicians have wounded themselves while operating upon lepers and attending women in labor.(4, 5)

5. All but one of the numerous attempts that have been made to inoculate man experimentally have been completely unsuccessful. Thus, in the years 1844–1858, Danielssen (1) repeatedly inoculated himself, several assistants, doctors, and syphilitic and favus patients, a total number of twenty, with leper nodules, which he placed under the skin, with blood, and with pleuritic exudate, without any positive result. Profeta also inoculated ten persons without result, and similar experiments of Bargilis were negative. One such experiment by Arning (6) was positive, though even this is not fully accepted by all authorities, owing to the fact that the experiment was performed in an endemic area and on a man who, as has been subsequently claimed, came from a leprous family.

As the result of these undoubted facts it must be admitted that if leprosy is transmitted by contact it is only with great difficulty, under very special circumstances, and usually only after long and intimate association with a leper. Children are believed to be especially susceptible to leprosy, yet Rodriguez has found that the average age at which children born of leprous parents and living in a leper colony were found to be positive

was 5 years 9 months. Calculating the incubation period (concerning which nothing can really be known) as three years nine months, the average age of infection would be 2 years. Close and intimate association with a leper for at least two years is therefore required on the average for the transmission of leprosy even to children. One would, therefore, naturally suppose that if leprosy were commonly transmitted by contact, practically all lepers would give a history of previous association with a leper. But this is not the case. McCoy,(7) who is himself an advocate of personal contact as the cause of leprosy, studied the histories of 1,060 lepers segregated at Molokai. Of these, association with lepers prior to segregation could be demonstrated in only 461, or 43+ per cent; while it could not be demonstrated in 599, or 56+ per cent. Callender and Bitterman, who investigated the histories of 259 lepers at San Lazaro Hospital, Manila, found only 36.9 per cent who admitted any previous contact with lepers, familial or otherwise; Muir(8) found that of 3,380 Indian lepers, only 58 per cent remembered contact with lepers prior to developing the disease; and similar figures have been obtained by other observers. Making all necessary allowances for ignorance in some cases and the tendency to deny previous association, it would seem that previous contact with lepers should be demonstrable in a higher percentage of cases if the disease were acquired by contact, especially as we have shown that such contact must generally be prolonged and intimate.

Still more convincing are the occasional cases that occur among Americans or Europeans in the Philippines, none of whom has been in intimate association with lepers, and few of whom have any recollection of contact, however casual, with a leper. I have personally known several such cases, and there is the history of one case in a lady, the wife of an officer.

All of these considerations throw doubt upon contact as the usual method of transmission and suggest the possibility that leprosy may more commonly be transmitted by some intermediate agency, such as the bites of certain insects. This possibility has, indeed, been considered by all authors, usually only to be dismissed rather summarily. Thus, McCoy(6) writes:

The second theory and a most alluring one is that of insect transmission. The fly, the louse, the bed-bug, the mosquito, and the itch-mite have all been under suspicion at one time or another, but when the affirmative evidence in each case has been submitted to careful laboratory and epi-

demiological study it has been found to be inadequate to account for the general transmission of the disease. So far as flies are concerned it cannot be denied that it is conceivable that they might carry leprosy bacilli on their legs, and it has been experimentally shown that they can carry the organisms of rat leprosy and other acid-fast organisms from place to place, but that this can be considered as more than a possible, or at most an occasional, mode of transmission remains to be shown.

With regard to blood-sucking insects the evidence is also flimsy. In the many insects of this sort that have been examined when caught in the environment of lepers or after feeding on leprous lesions the bacilli have been found so rarely as to make it unlikely that this means of conveyance occurs commonly. The lesions of leprosy are of such a nature that an insect can pierce through them into the blood stream and suck blood, without organisms being imbibed or even contaminating the piercing organs. There is one point in this connection that has not been sufficiently considered; during the febrile periods through which so many lepers pass, the bacilli may circulate in the peripheral blood, at times in large numbers, and it is possible that at such periods blood-sucking insects may take up the bacilli.

With regard to the itch-mite, we can only say that while lepers are very often infested with this parasite, many persons develop leprosy who have never had itch.

These objections are far from convincing. In answer to the statement that, "the blood-sucking insects become infected so rarely as to make it unlikely that this means of conveyance occurs commonly," it may be replied that leprosy is not a common disease, only about one per thousand of the inhabitants of the Philippines becoming infected. If a blood-sucking insect may transmit leprosy, it can only do so by biting a leper through a leproma and so becoming infected. Since the lepra bacilli cannot be supposed to undergo any cycle of development in an insect host, the insect can only transmit the disease mechanically, and must therefore bite another victim while its proboscis is still soiled with viable bacilli. This might readily happen with lice or fleas, which feed several times within twenty-four hours, or with mosquitoes and biting flies that have been interrupted while feeding. The difficulty of transmission in this manner favors this theory of transmission rather than rendering it improbable; for if insects could transmit leprosy as lice transmit typhus, fleas transmit plague, or mosquitoes transmit malaria, enormous numbers would develop leprosy. Again, the statements that "the lesions of leprosy are of such a nature that an insect can pierce them without becoming infected," is undoubtedly often correct. Nevertheless, the larger tubercles, which contain innumerable bacilli, are not so readily

pierced, and personal experiment has shown that lepra bacilli can be demonstrated in 40 per cent of the mosquitoes that are allowed to bite such lesions. If it is only rarely that an insect succeeds in biting over such a favorable area under natural conditions, this again agrees with the epidemiological facts.

On the other hand, a number of considerations may be advanced in favor of the theory of insect transmission. This theory not only accounts for the rarity of the disease, but it explains why long and close association with a leper is usually essential to transmission. It not only explains the increase in incidence of infection with increase in density of population as well as the personal contact theory, but it also explains the exceptions to this tendency, and the prevalence of the initial lesion on an uncovered portion of the body. Noc(1) made a point of this fact together with the appearance of leprosy, in his experience, only in the zones where there were mosquitoes, and demonstrated lepra bacilli in half of one hundred fifty culicine mosquitoes that had bitten advanced lepers. It explains the more frequent infection of those inhabiting the same house with a leper. Still more important, it affords an explanation for the occurrence of leprosy among persons who, so far as known, had no previous contact with lepers, certainly none but a most casual contact, which all experience has shown does not transmit the disease. Still further, the introduction of a few bacilli into the skin combined with the irritating saliva of the insect may afford just the circumstances needful to a successful inoculation, which have been so conspicuously absent in the numerous experimental inoculations on man. Finally, lepra bacilli have been found on numerous occasions and with a considerable degree of frequency in a number of biting insects, as will be seen from the following résumé of the literature, which moreover makes no claim to being complete and exhaustive.

Flies.—Joly(1) in Madagascar found bacilli in the intestinal tract and on the feet of flies that fed upon leprous ulcers, and believed that they might infect food. Currie(9) examined flies of several species found in the Hawaiian Islands, chiefly *Musca domestica*, and found that when permitted to feed upon leprous fluids these flies contain lepra bacilli in their intestinal tracts and fæces for several days, and that they may convey immense numbers of lepra bacilli to the skin, mucous membranes, and digestive tracts of healthy persons, and that we are justified in regarding these insects with grave suspicion as being one of

the means of disseminating leprous infection. Sandes(10) inclosed flies over ulcerated leprotic surfaces, and out of seventy, found lepra bacilli in the gastro-intestinal tract in two. In 1913 Leboeuf(11) found lepra bacilli in nineteen out of thirty-six flies captured in the rooms of lepers; and in 1916 Marchoux found the bacilli in the digestive tract and on the feet of flies, but that they died rapidly outside of the intestine. In 1917 de Buen,(11) out of a lot of fifty flies fed on ulcerating lepromata, found five slightly infected and twenty-six grossly infected. Mello and Cabral(11) in 1926 found that 40 per cent of the flies (*Musca bezzii*) captured from the leper asylum or fed on lepromata contained lepra bacilli in their intestinal contents, while it was impossible to find any acid-fast bacilli in those flies captured in other places.

Thus there is a very considerable accumulation of evidence that flies become infected with lepra bacilli. However, non-biting flies could only transmit the disease by contact or by infecting food, methods of transmission that we have already considered as incapable of explaining all the known facts concerning the epidemiology of leprosy. In this discussion we are more interested in biting insects, among which bedbugs, lice, fleas, and mosquitoes may be considered.

Bedbugs.—Bedbugs have been incriminated by several writers who have found lepra bacilli in them, while several other investigators have failed to find them.

Goodhue(12) was apparently the first to find lepra bacilli in the common bedbug (*Cimex lectularia*) and writes—

> I believe that the Cimex is more of a factor in the spread of leprosy among the natives than the gnat, for the following reasons, viz., the bedbug's invasion is noiseless and insidious, made during the sleep of the victim, and secondly, the beds and bedding used in a leper family, whether the leper is dead or segregated, are occupied by clean persons without adequate disinfection.

Ehlers, Bourret, and With (13) examined seventy-one bedbugs that had bitten lepers, in none of which were lepra bacilli found with certainty, although they reported three as doubtful.

Sandes(10) examined seventy-five bedbugs that had bitten lepers and found lepra bacilli in twenty of them, often in considerable numbers (twelve in one field). These bacilli do not readily disappear but can be found up to sixteen days after the insects are fed. They were also found in smears made

from the mascerated head and proboscis five days after feeding. Acid-fast bacilli were not found in bugs collected from nonleper sources. Sandes concludes that there is reason to believe that the bedbug constitutes a very important agent in the transmission of leprosy.

Long(14) also regularly found lepra bacilli in bugs that had bitten lepers, while control bugs were negative. Long also reported a case in a native who so far as known had never been in direct contact with a leper, but who had on several occasions slept in the bed of a leper in a different town and was severely bitten by bugs there.

Skelton and Parham(15) examined seventy-five bedbugs caught on beds at a leper asylum and with one doubtful exception found no lepra bacilli in them. This, however, is quite a different experiment from permitting the bugs to bite lepers. However, Thompson(16) fed bedbugs on cases of leprosy on several occassions, and of one hundred one bugs so fed, was unable to find lepra bacilli in any.

Again, however, lepra bacilli were definitely found by Johnston(17) five times out of three hundred fifteen bugs collected at Culion from the beds and houses of lepers. Only fifteen bugs were examined by direct smear, and acid-fast bacilli were found in one.

According to Mello and Cabral, de Buen in 1917 found bedbugs to be infected frequently, the percentage being 9.9 among bedbugs fed upon nodular lepers, and 0.88 among bedbugs collected in the beds of leper patients.

Mello and Cabral(11) themselves also investigated bedbugs and found that out of twenty bedbugs collected from the beds of lepers at the asylum of Mapuca, ten contained lepra bacilli in the intestinal tract. Thirty-six bedbugs were permitted to bite cases of nodular leprosy whose nodules had previously been shown to contain bacilli. Lepra bacilli were found in twenty-one, the number varying from one to twelve, and in the latter cases five globi were also found. Bedbugs from nonleprous sources were always negative. They also found that after an infective feed, the number of lepra bacilli commenced to diminish toward the fourth day.

Rodriguez(3) suggests the possibility of the bedbug as a transmitting agent, stating that acid-fast organisms considered to be lepra bacilli, have been found in 10 per cent of three hun-

dred two bedbugs fed on lepers, as reported by various workers, and 1 per cent of five hundred sixty-six specimens caught from lepers' quarters.

In the case of the bedbug, the evidence is conflicting, but there have been so many different positive findings that they must be considered as outweighing the negative findings. Not only do positive findings as a rule carry more weight than negative findings, but this is especially the case in an investigation of this character. A slide may be searched for an hour for lepra bacilli without result, and finally a definite clump may be found when the searcher is about to discontinue the search and call it negative. Obviously the more carefully nodules are selected, so that the bugs bite over an area containing numerous bacilli and the more painstaking the subsequent examination of the bugs, the higher will be the percentage in which lepra bacilli will be found in the intestinal contents.

Lice.—Joly (18) cites Sabrazés as suspecting lice of transmitting leprosy, and noted the prevalence of lice among the poorer classes in Algeria, these classes furnishing the greater number of lepers in that country.

Ehlers, Bourret, and With (13) examined twenty lice that had bitten lepers, of which nineteen were negative, while one was classed as doubtful. They found "three or four acid-fast, extra cellular bacilli," which they did not regard as characteristic lepra bacilli. However, it seems probable that they were, since no such acid-fasts were found in lice that did not bite lepers.

McCoy and Clegg (19) state:

> In some recent work in connection with the study of the possibility of the transmission of leprosy by animal parasites, we found a large number of acid-fast bacilli in smears made from two lice (*Pediculus capitis*) taken from an advanced case of nodular leprosy. In morphology, grouping, and tinctorial characteristics, the organisms found in these insects were indistinguishable from the leprosy bacillus. There was a leproma on the forehead adjacent to and invading the scalp . . . We have examined lice from several other cases of leprosy but with uniformly negative results.

From the above, it will be seen that although the evidence that lice may contain leprosy bacilli is not so extensive as for some other insects, the statement by McCoy and Clegg is very definite. We must assume that under the proper circumstances lice do become infected, and the louse must be considered a possible though probably not frequent vector of leprosy.

Fleas.—Fleas are very difficult to handle and to keep alive, and relatively few examinations of them have been made,

yet these are quite suggestive. Sandes(10) examined sixty fleas that had bitten lepers and found acid-fast bacilli corresponding to lepra bacilli in two of them. Ehlers, Bourret, and With(13) found lepra bacilli in one out of thirty-one fleas fed upon lepers.

Mosquitoes.—Leloir (Traite pratique et theoretique de la lepre, Paris, 1886) believed mosquitoes to be possible vectors of the infection. Arning (Archiv. f. Dermat. und Syph. 1891, No. 1, Congress de Berlin) remarks that leprosy and mosquitoes invaded the Hawaiian Islands at almost the same time. Blanchard (Bull. de l'Acad. de Med. July 30, 1905) states that leper countries are also usually mosquito countries. Hallopeau (Bull. de l'Acad. de Med. July, 1901) and Chantemesse (Bull. de l'Acad. de Med. July 30, 1901) favored the hypothesis that leprosy is transmitted by culicines.(20) These writers based their argument upon theoretical considerations.

Noc (Ann. d'Hyg. et de Med. Col. July–Sept. 1903, p. 481) not only pointed out that the first lesion of leprosy usually occurs on uncovered portions of the body, and that lepers usually only occur in countries where mosquitoes are numerous, but examined mosquitoes and found lepra bacilli in half of one hundred fifty culicine mosquitoes.

Goodhue(12) found lepra bacilli in considerable numbers in a few out of a large number of *Culex pungens* caught at random from leper houses. Ehlers, Bourret, and With(13) examined twelve *Stegomyia fasciata* Fabricius (*Aëdes aegypti* Linnæus) and found in one not only numerous single lepra bacilli, but also a globus. Currie(9) examined four hundred ninety-three mosquitoes collected from the rooms of lepers and found no acid-fast bacilli in any of them. He concludes, therefore, that mosquitoes feeding under natural conditions, imbibe lepra bacilli so rarely that this insect is of no importance in the transfer of the disease. This conclusion cannot be accepted, for Currie's negative results are balanced by the positive results of Goodhue which were also obtained on mosquitoes collected at random. As Currie himself says, if mosquitoes do contain the bacilli, the mechanism for the transfer of the bacilli is complete and the insect *may* be a factor in the transmission of the disease.

Supposing mosquitoes to be the usual method of transfer, the fact that they become infected so rarely under natural conditions of biting, is a good explanation of the fact that only 5 per cent of the persons in close association with lepers ever develop leprosy.

Ticks.—According to Mello and Cabral(11) ticks have been examined in Brazil by Rodolpho who has found lepra bacilli in their intestines as long as thirteen days after a feed upon a patient suffering from leprotic fever.

Sarcoptes scabei has been suggested as a probable cause by several investigators, but without finding lepra bacilli on them. Most writers dismiss this possibility with the statement that most lepers have never had the itch. This by no means excludes the probability that infection may at times be carried by this parasite, whose known habits strongly favor this possibility. Such a method of transfer would explain the case quoted by Manson-Bahr(21) "as an instance that can only be explained by contagion." This case was an Irishman who had acquired the disease in the West Indies. After his return to Ireland, he slept in the same bed as his brother, who moreover, sometimes wore the leper's clothes. This brother, who had never been out of the United Kindom, became a leper.

Rodriguez(3) reports three cases in which the first lesion of leprosy developed from a scabies scar. This is fairly convincing evidence that infection may occur in this manner.

Demodex folliculorum.—Borrel(22) suggested this parasite as a transmitting agent. Ehlers, Bourret, and With(13) found in their sections of lepromata numerous hair follicles containing free lepra bacilli and epithelial cells containing globi. At one place they found a *Demodex* surronded by a great quantity of lepra bacilli, and believed that their findings afforded support for Borrel's hypothesis that the *Demodex* might convey the infection.

From this summary of the literature it is evident that leprosy *may* be transmitted by a wide variety of biting insects and skin parasites. It may well be that no one of these parasites is the sole transmitting agent, but that several or all of them may serve to transmit the infection under favorable circumstances. The familiar tendency of the disease, the value of isolation, the rarity of the infection among those exposed, the location of the first lesion on an exposed part of the body, and even cases cited as sure proof of the contagion theory can be readily explained by assuming transmission by one or more of these insects. Considering also the great difficulty in explaining the incidence of the disease on the theory of contagion, it would seem that

more authorities should agree with Castellani and Chalmers(23) who state that "everything in the history of the disease appears to us to favor its spread by animal agency."

EPIDEMIOLOGICAL OBSERVATIONS

Desiring to obtain any information that might throw light upon the method of transmission of leprosy, a study was made of the incidence of leprosy in the Philippines. Since the actual number of lepers is not known with certainty, the study was based upon 16,551 lepers diagnosed and segregated during the twenty-one years 1906–1926. A tabulation of these lepers, by provinces, was furnished me through the courtesy of Dr. Lopez Rizal, of the Philippine Health Service, together with the estimated population of all the provinces during these years. From these figures, the average annual admission rate per thousand was worked out for each province (Table 1).

GEOGRAPHICAL DISTRIBUTION

The incidence of leprosy by provinces is very irregular. Albay, Sorsogon, and Camarines Sur have high rates (0.156, 0.135, 0.080), while Camarines Norte and Tayabas, adjoining, have low rates (0.030, 0.035); Zambales, Bulacan, and Nueva Ecija have relatively high rates (0.169, 0.090, 0.067), while the intervening provinces Tarlac, Pampanga, and Pangasinan have the low rates of 0.041, 0.039, and 0.016; Ilocos Sur has a rate of 0.022, while Ilocos Norte on one side has a rate of 0.045 and La Union on the other side a rate of 0.057. These examples show that leprosy does not spread evenly among the population by contiguity, but that there are local conditions operative which produce a high incidence of leprosy in certain provinces while people in neighboring provinces who are separated only by an imaginary line have a low incidence.

It has been shown moreover that this distribution is not temporary but has always existed. The disease was especially prevalent in the same localities before the Spanish colonization, and under the Spanish administration lazarettos were early established in Cebu and in Palestina, near Naga, Camarines Sur, as well as in Manila. If leprosy were transmitted solely by contact, it is difficult to understand this irregular distribution among people of neighboring provinces who intermingle freely with each other.

HUMIDITY

It was suggested by Rogers(24) that the incidence of leprosy in India depended upon rainfall and humidity and was relatively rare in dry climates. No part of the Philippines is dry, and Guerrero(25) showed clearly that this factor was unimportant in the Philippines. Baguio, Mountain Province; Surigao, Mindanao; and Paracale, Camarines Norte, are the stations having the highest average relative humidity, yet they have very low rates of leprosy incidence (0.015, 0.009, 0.030). On the other hand, the stations at Cebu, Vigan, Manila, and San Isidro, which record the lowest average humidities, are in provinces or regions where the rates are among the highest. Twenty-seven per cent of all the lepers in the Philippines come from the small island Cebu.

DENSITY OF POPULATION

From the Statistical Bulletin, published by the Department of Commerce and Communications, the areas of the provinces in square miles were obtained, and the average population per square mile for each province was calculated for the same years (1906–1926). The figures so secured, together with the average annual leper rate per thousand, are shown in Table 1. The average leper rate per thousand was then charted by provinces in the order of density of population as shown in fig. 1. From this analysis two deductions may be drawn, namely:

1. As has been previously stated by several authorities and especially by Guerrero,(25) there is a definite tendency for leprosy to increase with density of population. Thus provinces having from 9 to 68 persons per square mile had an average annual admission rate of 0.042 per thousand, in provinces having 101 to 199 persons per square mile the similar rate was 0.068, in provinces having from 222 to 278 persons per square mile the rate was 0.083, while with a population of 305 and upward the rate was 0.140.

2. A glance at the chart (fig. 1) will show that the curve is exceedingly irregular, some localities having a dense population (La Union 448, Pampanga 305, Pangasinan 278, Batangas 255, Marinduque 156) had exceedingly few lepers admitted annually, and Manila, undoubtedly the most densely populated area in the Philippine Islands, had a lower rate than Cebu, Ilo-

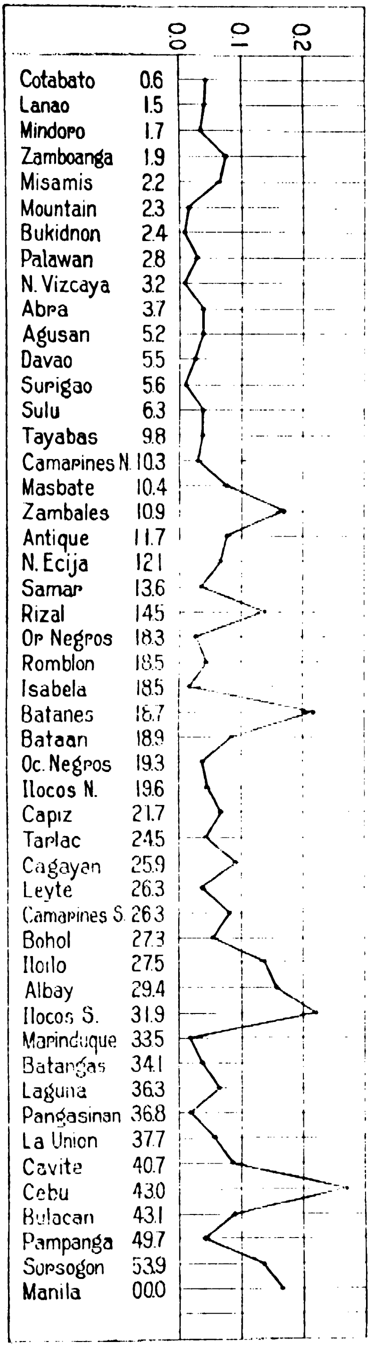

FIG. 2. Average annual leper admission rate per thousand. Provinces arranged in order of percentage of cultivated land.

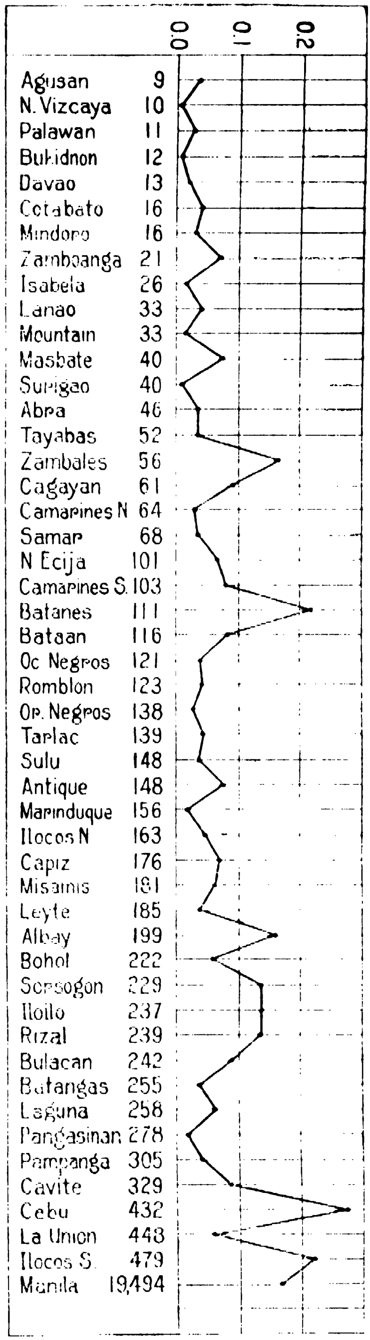

FIG. 1. Average annual leper admission rate per thousand for each province. Provinces arranged in order of density of population.

cos Sur, of Batanes. Cebu, which is very densely populated (432 per square mile), had the highest rate of all, a rate higher than the rate for Manila whose population is 19,494 per square mile. On the other hand, a number of provinces having a comparatively sparse population (Zambales 56, Batanes 111, Albay 162) had unusually high admission rates.

This indicates that density of population is only one factor and not the most important factor in the transmission of leprosy, a fact that is inconsistent with the contact theory; for if leprosy were transmitted always or even usually by contact, the rate of infection should increase more regularly with density of population.

Population is not evenly distributed with the same number of inhabitants for each square mile as assumed in fig. 1, and several attempts were made to determine the population distribution more accurately.

Thus, it may be assumed that more people live upon cultivated than upon uncultivated land. The percentage of cultivated land in each province as given by the Statistical Bulletin was arranged in order from the lowest to the highest and charted with the leper rate for the corresponding provinces (fig. 2). The curve of leper incidence plotted in this way agrees in general with fig. 1 and shows the same irregularities.

Figure 3 was then prepared on the assumption that in provinces having less than 7 per cent of cultivated land the population would be evenly distributed, and that in provinces having more than 7 per cent the entire population would be concentrated on the cultivated land.

Land is classified by the Statistical Bulletin as commercial forest, noncommercial forest, swamp land, cultivated land, and grassland. Inhabitants cannot be numerous in forest except in the case of the uncivilized tribes. Therefore, fig. 4 was prepared on the assumption that in provinces having less than 20 per cent cultivated land and grassland the majority of the population was evenly distributed, and that in provinces having more than 20 per cent cultivated land and grassland the total population lived upon this land. Figures 3 and 4 agree in general with figs. 1 and 2 and are quite as irregular. In fact, the closer we approach the actual density of the population, the more irregular becomes the curve of the leprosy incidence.

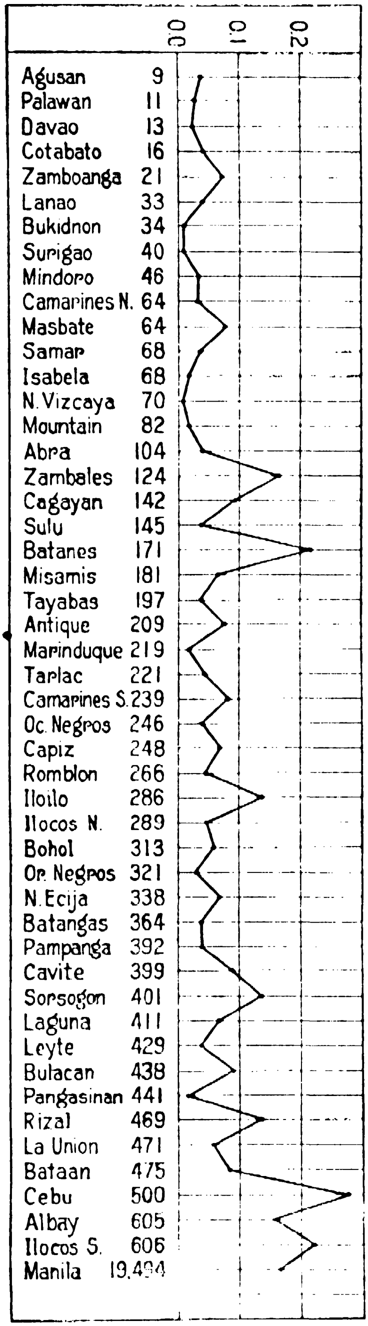

FIG. 4. Leper rate charted on assumption that population lives on cultivated land and grassland.

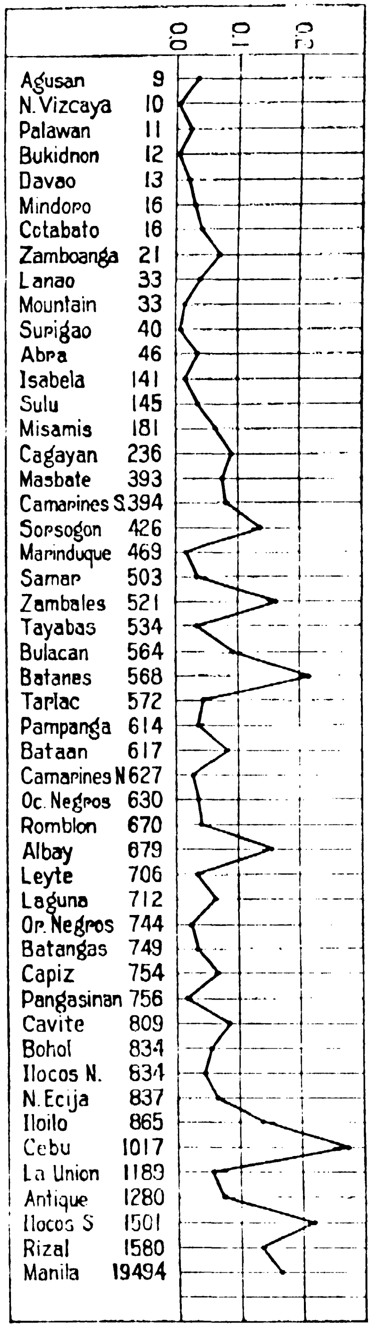

FIG. 3. Leper rate charted on assumption that population lives on cultivated land.

TABLE 1.—*Provinces of the Philippines arranged alphabetically and showing for each the total population, the area in square miles, the population per square mile, and the average annual leprosy admission rate.*

Province.	Average population, 1906–1925.	Area in square miles.	Population per square mile.	Annual leper rate per thousand.
Abra	68,776	1,475	46	0.037
Agusan	40,980	4,294	9	.035
Albay Catanduanes	307,589	1,543	199	0.156
Antique	151,100	1,011	148	0.074
Bataan	56,150	480	116	.083
Batanes	8,214	74	111	0.218
Batangas	324,572	1,270	255	0.037
Bohol	341,492	1,536	222	0.058
Bukidnon	48,544	3,871	12	0.008
Bulacan	244,450	1,007	242	0.090
Cagayan	183,707	3,007	61	0.090
Camarines Norte	50,176	779	64	0.030
Camarines Sur	214,900	2,072	103	0.080
Capiz	279,928	1,710	176	0.068
Cavite	153,077	464	329	0.088
Cebu	816,917	1,867	432	0.275
Cotabato	163,242	9,620	16	0.041
Davao	100,126	7,486	13	0.021
Ilocos Norte	211,524	1,293	163	0.045
Ilocos Sur	211,747	442	479	0.220
Iloilo	485,397	2,040	237	0.137
Isabela	106,038	4,052	26	0.016
Laguna	186,651	722	258	0.062
Lanao	81,982	2,439	33	0.040
La Union	156,941	350	448	0.057
Leyte	558,344	3,005	185	0.035
Manila	272,922	14	19,494	0.165
Marinduque	55,884	356	156	0.017
Masbate	62,995	1,545	40	0.079
Mindoro	65,801	3,928	16	0.031
Misamis	186,683	1,030	181	0.061
Mountain Province	215,345	6,447	33	0.015
Nueva Ecija	209,484	2,069	101	0.067
Nueva Vizcaya	35,838	3,530	10	0.005
Occidental Negros	379,893	3,125	121	0.039
Oriental Negros	259,065	1,902	136	0.027
Palawan	62,732	5,619	11	0.029
Pampanga	251,201	823	305	0.039
Pangasinan	510,888	1,944	278	0.016
Rizal	215,502	899	239	0.135
Romblon	62,382	505	123	0.011
Samar	358,152	5,234	68	0.034
Sorsogon	167,465	729	229	0.135
Sulu	157,203	1,082	145	0.034
Surigao	116,110	2,889	40	0.009
Tarlac	164,911	1,178	139	0.041
Tayabas	200,847	3,839	52	0.035
Zambales	80,888	1,421	56	0.169
Zamboanga	138,000	6,383	21	0.072

TABLE 2.—*Provinces of the Philippines arranged by per capita income from nine principal crops and fishing and showing the annual average leprosy admission rate for each province.*

Province.	Per capita income.	Annual admission rate for leprosy per thousand.	Province.	Per capita income.	Annual admission rate for leprosy per thousand.
	Pesos.			*Pesos.*	
Batanes	6	0.218	Oriental Negros	37	0.027
Sulu	6	0.034	Ilocos Norte	39	0.045
Cotabato	9	0.041	Misamis	42	0.061
Palawan	10	0.029	Mindoro	45	0.031
Rizal	15	0.135	Cagayan	46	0.090
Masbate	17	0.079	Pangasinan	48	0.016
Antique	19	0.074	Surigao	49	0.009
Bukidnon	19	0.008	Albay	50	0.156
Bohol	22	0.058	Tarlac	51	0.041
Zambales	22	0.169	La Union	52	0.057
Mountain Province	23	0.015	Sorsogon	53	0.135
Samar	24	0.054	Camarines Sur	54	0.080
Cebu	25	0.275	Isabela	54	0.016
Zamboanga	27	0.072	Agusan	58	0.035
Batangas	27	0.037	Marinduque	59	0.017
Lanao	28	0.040	Nueva Vizcaya	65	0.005
Romblon	31	0.041	Bataan	66	0.083
Leyte	32	0.035	Camarines Norte	70	0.030
Abra	33	0.037	Pampanga	82	0.039
Bulacan	34	0.090	Tayabas	84	0.035
Ilocos Sur	36	0.220	Davao	87	0.021
Capiz	37	0.068	Laguna	95	0.062
Cavite	37	0.088	Nueva Ecija	95	0.067
Iloilo	37	0.137	Occidental Negros	162	0.039

These illustrations, which might be multiplied, show that some local condition other than contiguity or density of population is the most important factor influencing the transmission or nontransmission of leprosy. Lepers exist in all of the provinces, but in some, especially Cebu, Ilocos Sur, Albay, Batanes, and Zambales, conditions other than density of population facilitate the transmission of the disease.

WEALTH

The Statistical Bulletin gives the total annual value of the nine principal crops (rice, abacá, sugar cane, tobacco, coconuts, corn, maguey, cocao, coffee), together with the annual income from the fishing industry, by provinces. From these figures the per capita annual income was calculated for each province (Table 2). The provinces were then arranged in order from the lowest to the highest and charted with their average annual leper rates (fig. 5). From this it will be seen that there is a

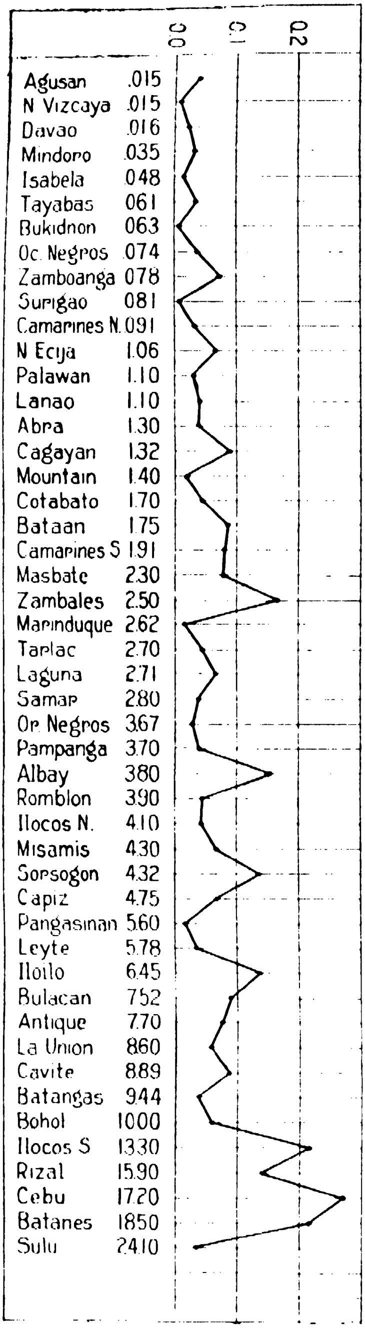

FIG. 6. Leper rates charted by provinces. Provinces arranged in order of the ratio between density of population and per capita income.

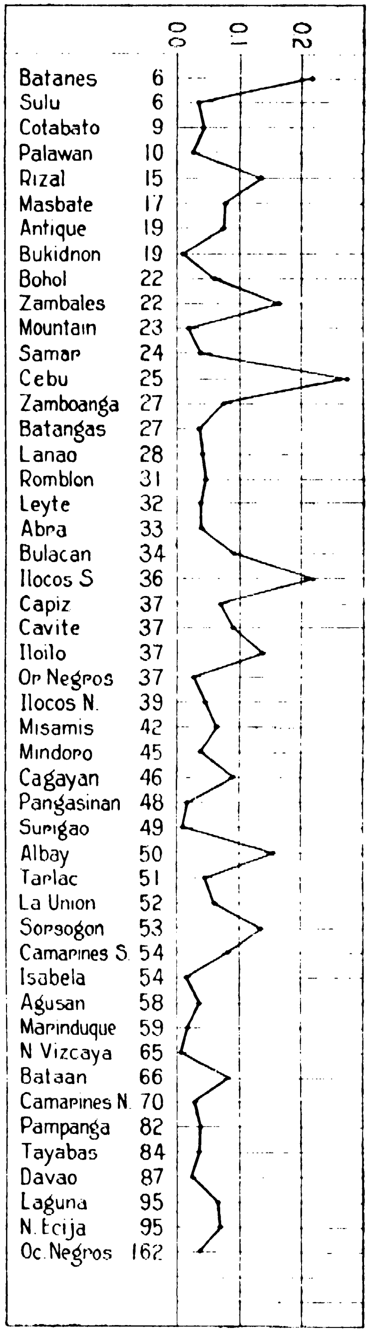

FIG. 5. Leper rates charted by provinces arranged in order of per capita annual income.

distinct tendency for the occurrence of higher leper rates among the poorer people. If the forty-eight provinces are equally divided, the first twenty-four, receiving the lower incomes, have an average annual leprosy rate of 0.083; while the twenty-four provinces receiving the higher incomes have an average annual rate of 0.049.

This might be reasonably expected since, other things being equal, well-to-do people live under conditions of better sanitation and have a better diet than poor people, but the chart again is very irregular and shows clearly that this is a minor factor governing the incidence of the disease. These irregularities are not in the least corrected even when both factors of density of population and annual income are taken into consideration, as shown by fig. 6 in which the provinces are charted in the order indicated by a ratio between density of population and per capita income.

TABLE 3.—*Provinces of the Philippines arranged alphabetically and showing for each the beriberi mortality rate, 1920–1924, and the average annual leprosy admission rate.*

Province.	Mortality rate from beriberi per thousand, 1920–1924.	Admission rate for leprosy per thousand.	Province.	Mortality rate from beriberi per thousand, 1920–1924.	Admission rate for leprosy per thousand.
Abra	0.168	0.037	La Union	0.996	0.057
Agusan	0.509	0.035	Leyte	1.698	0.035
Albay			Marinduque	2.147	0.017
Catanduanes	2.315	0.156	Masbate	0.439	0.079
Antique	0.670	0.074	Mindoro	2.883	0.031
Bataan	3.547	0.083	Misamis	2.293	0.061
Batanes	0.243	0.218	Mountain Province	0.131	0.015
Batangas	2.620	0.037	Nueva Ecija	1.314	0.067
Bohol	0.759	0.058	Nueva Vizcaya	0.463	0.005
Bukidnon	0.308	0.008	Occidental Negros	1.076	0.039
Bulacan	4.299	0.090	Oriental Negros	1.665	0.027
Cagayan	1.098	0.090	Palawan	0.130	0.029
Camarines Norte	1.557	0.030	Pampanga	2.945	0.039
Camarines Sur	1.559	0.080	Pangasinan	1.077	0.016
Capiz	0.891	0.068	Rizal	3.398	0.135
Cavite	5.131	0.088	Romblon	0.788	0.041
Cebu	1.202	0.275	Samar	1.196	0.034
Cotabato	0.971	0.041	Sorsogon	1.113	0.135
Davao	0.883	0.021	Sulu	0.057	0.034
Ilocos Norte	0.736	0.045	Surigao	0.797	0.009
Ilocos Sur	0.615	0.220	Tarlac	2.366	0.041
Iloilo	0.578	0.137	Tayabas	2.173	0.035
Isabela	0.859	0.016	Zambales	2.009	0.169
Laguna	3.073	0.062	Zamboanga	0.910	0.072
Lanao	0.097	0.010			

Muir(26) has stated that for India the most outstanding determinant of leprosy is dietetic. In all the regions where the incidence of leprosy was high there was a shortage of essential foods leading to partial starvation, which was usually associated with the consumption of decomposing food, especially bad fish. A bad diet must undoubtedly be another predisposing cause of leprosy, but cannot be the main determining factor in the Philippines. Without denying that the diet of many Filipinos is deficient, a fact that is indicated by the incidence of beriberi, there is no such difference in the food habits of the people of the different provinces as would account for a leper admission rate of 0.156 in Albay as compared with 0.037 in Batangas, or 0.08 in Camarines Sur and 0.03 in Camarines Norte; nor does the incidence of beriberi show any real correlation with the leper rates, as indicated by Table 3.

None of the factors that have been considered can be the main factor influencing the prevalence of leprosy, nor can it be expected that we can determine the conditions responsible for the transmission of the disease from such limited data. So far as it goes, the evidence is against transmission by contact and is so far favorable to the hypothesis that leprosy is an insect-borne disease.

EXPERIMENTAL

EXAMINATION OF MOSQUITOES

While it has been shown that several insects may be possible vectors of leprosy, it was believed that mosquitoes should be investigated first; since, if the disease is insect borne, the cases of leprosy that occur without known contact with previous lepers can be explained best by infection through a flying, biting insect. The following method was first employed to determine the percentage of mosquitoes that might be infective after biting lepers.

Aëdes aegypti was selected because the insects of this species bite freely during the day, and the mosquitoes were raised in the laboratory from the eggs. Freshly emerged females that had never bitten were collected in test tubes, one mosquito in each tube, and taken to San Lazaro Hospital where they were permitted to bite lepers. The lepers were selected cases of macular and tubercular leprosy. A suitable area on the skin of the leper was selected, and examined microscopically. Only if many bacilli were present in the area selected were the mos-

quitoes permitted to bite. The test tube was then applied over this area, and the mosquito allowed to bite until filled with blood. In some instances the mosquito was interrupted and allowed to bite several times before it had completed its feed. I am indebted to the director of the hospital and to Doctor Tietze and Doctor Pardo for the facilities afforded for this work. Ten different lepers were used on different days, allowing about ten mosquitoes to bite on different favorable areas on each leper. As soon as the mosquitoes had all bitten, they were carried in the stoppered test tubes to the laboratory and killed by dropping chloroform upon the stoppers. The wings and the legs were then removed, and the blood from the abdomen was expressed and spread upon a glass slide. These slides were then stained in the usual way with carbol fuchsin, decolorized with 20 per cent nitric acid and alcohol, counterstained with methylene blue, and examined for lepra bacilli.

Undoubted lepra bacilli were found in 41 per cent of this series of approximately one hundred mosquitoes. They were recognized as lepra bacilli not only because they were acid-fast and of characteristic morphology and size, but because of their characteristic grouping. In several instances entire globi were found. No acid-fast organism of any kind was found in ten control mosquitoes that were similarly examined after being permitted to bite normal men.

During the course of this work it appeared that mosquitoes were more apt to become infected if they bit over tubercles where they were obliged to insert the proboscis through a thick leprous infiltration in order to obtain blood, or when they were interrupted so that they were obliged to bite several times. With the experience so gained, it would perhaps be possible to obtain infection of the mosquito in nearly 100 per cent of cases, by proper selection of lepers and technic of biting. However, in a state of nature comparatively few mosquitoes would become infected, so that the precise percentage infected by this experimental method is an academic question.

The important point is that this experiment confirms the observations of others that have been quoted, and shows that under proper circumstances mosquitoes certainly might transmit the disease.

It is not known how long lepra bacilli in the proboscis of the mosquito would remain viable, but from the nature of the organism it may certainly be assumed that they would remain

viable for at least several hours, and that if during this period the mosquito bit another victim, as it would surely do if interrupted in its first feed, these lepra bacilli would almost certainly be injected with the saliva of the mosquito into the second host. This mechanism possesses all the points necessary to explain the transmission of a disease having the known characteristics of leprosy, especially the fact that it is transmitted only with great difficulty.

TRANSMISSION EXPERIMENT

Leprosy has never been successfully transmitted to animals, and experimentally only once to man. Accurate information concerning the method of transmission might be of the greatest value in the control and eventual eradication of the disease. Insect transmission is at least possible and the considerations presented above indicate that it is even probable. For these reasons a human experiment was believed to be justifiable.

This proposition was presented to Governor-General Wood, who after due consideration authorized the experiment. Accordingly, three volunteers were secured from Bilibid. The nature of the experiment was explained to these men who agreed in writing to submit to inoculation, and it was promised that should they develop leprosy they would be released from Bilibid and sent to Culion where they would receive treatment. Since they would be kept under constant observation during the experiment, the disease would be detected early should it occur and the prospect of cure would be excellent. Only long-term prisoners were selected who had little to lose and much to gain, for the Board of Pardons had assured me that they would give these men favorable consideration in view of their coöperation in this experiment. It would seem to most people that not many would volunteer for such an experiment, but on the contrary there was a considerable number of volunteers; many were unsuitable for one or more reasons. The essential conditions to the acceptance of a volunteer were as follows:

1. He must freely volunteer, knowing the nature of the experiment.
2. He must be a long-term prisoner.
3. He must be a young man in perfect health.
4. There must be no leprosy in the family nor any history of contact with lepers. He must have been at least two years in isolation from possible infection in Bilibid, to exclude the

possibility of the development of leprosy from any other source than the experiment.

It was determined to use one man as a control, using an intradermal method of inoculation, a method that so far as known had not been used in previous human experiments. The other two men were used to test the possibility of mosquito transmission. The protocols of the experiments follow:

I. José Malaborbor, Bilibid prisoner, 24 years old, sentenced to life imprisonment for robbery and homicide. He was born in Santo Tomas, Batangas. Father and mother are living and well, and four brothers and two sisters are living and well. No lepers in the family. States that he saw a leper once in 1910, but denies any contact with lepers at any time. Has been in Bilibid for the past four years (since 1923).

Personal history.—Has always been well except that he had a fever of some kind in 1915. No history of other illness.

Physical examination.—Figure slight but muscular and apparently well nourished. Skin shows numerous tattoo marks, and scars on the knees, but no eruption of any kind and the skin is otherwise normal. No thickening of the nerves, no anæsthesia, nose and throat normal. No abnormalities of any kind detected. Photographs made, front and rear views.

Inoculation.—March 29, 1927. The inoculation was made using material from the arm of Basilio Lat, an untreated leper from San Lazaro, but without any contact between leper and prisoner other than the inoculation. A slide made from a tubercle on the arm of Basilio Lat showed large numbers of lepra bacilli and globi. This tubercle was incised and scraped with a scalpel, and the scrapings were placed in a sterile watch glass where they were diluted with 0.1 cubic centimeter of sterile salt solution. A small portion of this bloody fluid was spread on a slide and stained, showing numerous scattered lepra bacilli. This material was then taken up in a sterile syringe and with a fine needle injected into the skin of the back of Malaborbor, in the mid line one-half inch above a tattooed mark. A large white plaque formed immediately about the needle, showing that the injection was truly intracutaneous. Operation completed at 9.50 a. m.

March 30–31, 1927. Negative. No acute infection.

April 16, 1927. Three pinpoint papules over area of inoculation.

May 19, 1927. Papules gone. Skin normal.

Monthly examinations made thereafter to include June, 1928, have been completely negative. No local or general symptoms of leprosy.

II. Alfonso Par, Bilibid prisoner, 26 years old with a 27-year sentence. He was born in Unisan, Tayabas. Father living and well. Mother died in 1919, cause unknown. No leprosy in the family, and so far as known he has never seen or been in contact with a leper. He has been in Bilibid during the past nine years. He has never had any kind of illness.

Physical examination.—A very robust, muscular man, who is employed as a blacksmith. There are scars on the right thigh, waist, and left side from injuries, a tattoo mark on the right arm, and scars from acne on the face. Skin oily with numerous comedones, but otherwise normal. No thickening of nerves, no anæsthesia, nose and throat normal. No other abnormalities detected. Photographs made, front and rear views.

Inoculation.—April 18, 1927. Two untreated lepers from San Lazaro were examined, and suitable tubercles were selected in both cases that contained many lepra bacilli as shown in smears. These lepers were then brought to a laboratory in the Bureau of Science. Alfonso Par was also brought from Bilibid to the same room, but the lepers and the prisoner were seated on chairs at opposite sides of the room and were never in the slightest contact. Freshly emerged mosquitoes (*Aëdes aegypti*) were caught in sterile test tubes. A mosquito was then permitted to bite one of the selected areas on one of the lepers, and when it was about half filled, it was dislodged by shaking the tube; the tube was plugged and carried at once to the prisoner. The presumably infected mosquito was then permitted to bite the prisoner on the skin of the back in the mid line between the shoulder blades. This site was chosen because the skin is unusually thick in this locality, and because it is a situation that cannot be easily reached so that no feigned eruption could be produced. The mosquito was permitted to feed upon the experimental subject until it was satisfied and left the skin. At times, the mosquito was interrupted in its feed, and allowed to bite a second or even a third time before completing its meal. This process was repeated with twenty-one mosquitoes, the operation requiring about three hours, when the prisoner was returned to Bilibid. The mosquitoes used

were then dissected and the contained blood smeared on slides to be examined later for the presence of lepra bacilli.

This operation was repeated on April 19, when twenty-one mosquitoes were again permitted to feed alternately upon one of the lepers and the prisoner. On each day half of the mosquitoes were permitted to bite each of the lepers. Therefore, at the conclusion of the experiment, the prisoner had been bitten by forty-two mosquitoes that had just bitten a leper over an area known to be infective, twenty-one mosquitoes from each leper. All of the mosquitoes were applied to the prisoner over a small area, of approximately 2 square inches, in the mid line of the back, an area that could be readily recognized subsequently, should any lesion develop.

This prisoner has been kept under continuous observation, being examined monthly, but up to June 30, 1928, fourteen months later, has developed no sign of leprosy, and has remained entirely well and continuously employed at his trade of blacksmith.

III. Benito Lavandilla, Bilibid prisoner, 21 years old, sentenced to life imprisonment for theft with violence and murder. His father was killed in a fight, his mother is living and well. One brother and one sister also living and well. No leprosy in the family, and no previous contact with lepers known. Has been in Bilibid five years.

Physical examination.—A young man of slight physique, but well nourished and healthy, and employed as a clerk. Skin normal, no thickening of nerves, no anæsthesia, nose and throat normal. No abnormalities detected.

Inoculation.—June 7, 1927, was bitten by twenty-three freshly emerged mosquitoes (*Aëdes aegypti*) that had previously bitten Basilio Lat, the leper used in Experiment I, and following precisely the technic described in Experiment II. Lat had been under treatment with chaulmoogra for a month, and the tubercles on the skin were much reduced, and slides showed that many of the bacilli had become granular.

June 9, 1927. Again bitten with thirty mosquitoes fed back and forth with Quisquino, a newly admitted and untreated leper whose lesions showed many bacilli.

June 24, 1927. Again bitten with twenty-nine mosquitoes fed back and forth with Alcantara, a newly admitted and untreated leper of several years standing and having tubercles containing many lepra bacilli.

On July 1 the skin over the area on the back where the mosquitoes had been applied was normal. This prisoner has been kept under continuous observation, and examined monthly, but up to June 30, 1928, has developed no sign of leprosy. He remained in perfect health until April 20, when he developed an acute diarrhœa of unknown origin, but probably some infection. Stool examination was negative except for the finding of several hookworm eggs. Recovered in a few days and has been well since (June 30, 1928).

This experiment cannot yet be called negative, for none of the three prisoners has been under observation long enough to exclude the possible development of leprosy. The notes have been compiled at this time because of my immediate departure to the United States, but the observation will be continued by my successor.

It should be noted, that even if this experiment should remain completely negative, it would in no wise disprove the theory that leprosy may be transmitted by insects. It does not even prove that the disease is not transmitted by mosquitoes, since it is possible that neither of the two men selected for the trial of mosquito transmission was susceptible to leprosy. It is highly probable that many individuals are not susceptible and that this accounts for the failure of the numerous previous negative inoculation experiments. It would appear that further experiments of this kind, using other biting insects and especially bedbugs, would be desirable, and, from the great importance of the subject, justifiable as well.

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ILLUSTRATIONS

TEXT FIGURES

INFLUENCE OF DENSITY OF POPULATION ON DEVELOPMENT OF LEPROSY

FIG. 1. Chart showing average annual leper admission rate per thousand for each province. Provinces arranged in order of density of population.

2. Chart showing average annual leper admission rate per thousand. Provinces arranged in order of percentage of cultivated land.

3. Chart showing leper rate charted on assumption that population lives on cultivated land.

4. Chart showing leper rate charted on assumption that population lives on cultivated land and grassland.

INFLUENCE OF WEALTH ON DEVELOPMENT OF LEPROSY

5. Chart showing leper rates charted by provinces arranged in order of per capita annual income.

6. Chart showing leper rates charted by provinces. Provinces arranged in order of the ratio between density of population and per capita income.

THE EFFECT OF THE ADMINISTRATION OF ALCOHOL UPON THE RESULT OF THE WASSERMANN TEST IN YAWS MONKEYS

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In 1911 C. F. Craig and H. J. Nichols(1) published observations regarding the effect of the ingestion of alcohol on the result of the Wassermann test in syphilitic patients, and those observations have since been confirmed by many observers and are of great practical importance because they have demonstrated that negative Wassermann tests in individuals who have, within one or two days of the collection of blood, ingested considerable amounts of alcoholic liquors are not dependable from the diagnostic standpoint.

There are serologic analogies between syphilis and yaws. Yaws patients show a positive Wassermann reaction as frequently as do syphilitics. Philippine monkeys infected with yaws material also show a positive Wassermann reaction in the course of the disease as does man.(2, 3)

The object of this investigation was to study further this serologic condition in experimental yaws monkeys.

PROCEDURE

I tested the Wassermann reaction in Philippine yaws monkeys before and after the administration of alcohol. At first alcohol was administered by mouth and under the skin at the same time, but as it was soon observed that the ingestion of alcohol by mouth or the injection of alcohol under the skin or into the muscles had, in every way, the same effect as to the result of the Wassermann test, the latter method was used in further experiments in order to simplify the procedure.

The experimental animals used in this investigation were Philippine monkeys infected experimentally with yaws strain Cadangan.(3) The actual Wassermann tests were performed by the workers of the division of biology and serum laboratory, Bureau of Science, who are performing the regular routine

Wassermann tests in this institution and were unacquainted with the source of the blood samples submitted to them and consequently unprejudiced as to the interpretation of the findings. Table 1 shows the results.

As the table shows, either the ingestion of about 20 cubic centimeters of 48 per cent alcohol given by mouth or the parenteral administration of about 3 cubic centimeters of 95 per cent alcohol has rendered a double-plus positive Wassermann reaction negative; that is, incomplete hæmolysis became complete when the Wassermann reaction was repeated with a new blood sample obtained within from twenty-four to forty-eight hours after the administration of alcohol. This negative result, artificially induced, became usually positive again when the test was repeated on the same animal after a further interval of seventy-two hours; that is, within ninety-six hours after the administration of alcohol. The effect of the administration of alcohol on the result of the Wassermann reaction became noticeable as early as one hour after the administration of alcohol (see W–6). The change in the result of the reaction was so marked that a double-plus reaction, just before the administration of alcohol, became negative in twenty-four hours after the administration of alcohol, while a four-plus reaction (that is, complete inhibition of hæmolysis) became one plus (slight inhibition of hæmolysis). This effect continued sometimes for forty-eight hours or more.

This observation, therefore, has a practical significance as it demonstrates that a careful inquiry as to whether or not yaws patients have ingested, within one or two days, considerable amounts of alcoholic liquors should be made before the collection of blood for the Wassermann test is attempted. If it so happened, they should be instructed to discontinue the use of alcohol and report at a later date for the test.

CONCLUSIONS

1. The results of these experiments show that with regard to the effect of alcohol on the result of the Wassermann test yaws behaves the same way as syphilis.

2. The results bring further proof of the identity of the Wassermann reaction in Philippine yaws monkeys and in syphilitic patients.

3. The yaws-infected monkeys are suitable experimental animals for the study of the nature of the Wassermann reaction and for the study of the effect upon the Wassermann reaction of

TABLE 1.—*Showing the influence of the administration of alcohol on the result of the Wassermann test in yaws monkeys.*

[++++, complete inhibition of hæmolysis; ++, incomplete inhibition of hæmolysis; +, slight inhibition of hæmolysis; ±, very slight inhibition of hæmolysis; —, complete hæmolysis.]

Designation of monkey.	Body weight.	Infection with yaws material.	First Wassermann test.	Dose of alcohol administered. By mouth, 48 per cent alcohol.	Under the skin, 95 per cent alcohol.	Into the muscle, 95 per cent alcohol.	Result of Wassermann test. Just before the administration of alcohol.	After the administration of alcohol.			
	g.			*cc.*	*cc.*	*cc.*		*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*
W-6	2,850	Oct. 21, 1927	Feb. 9, 1928	20	4		− −	1, ±	24, —	96, − −	
W-8	2,700	Oct. 25, 1927	Mar. 20, 1928	20			+ −	19, +	48, —	96, −	120, +
W-11	1,160	Nov. 7, 1927	Mar. 25, 1928	10			− −	[a]10, ±			
T-15	2,100	Sept. 17, 1927	Mar. 25, 1928		5		− −	48, —	72, ±	96, − − +	120, ±
W-16	2,570	Dec. 12, 1927	Mar. 26, 1928		3		±	24, ±	48, −	68, ±	96, ±
W-5	1,300	Oct. 18, 1927 / Mar. 2, 1928	Mar. 27, 1928		3		±	24, —	72, —	96, —	114, —
T-16	2,370	Sept. 20, 1927	Mar. 28, 1928			3	+	24, − −	48, −	72, −	120, + +
D-15	1,800	June 18, 1927	Mar. 28, 1928			2	+ + + −	24, −	48, −	72, + +	120, − + + +
F-31	2,500	Jan. 27, 1928	Mar. 28, 1928			4	+ + − +	24, − −	48, + − +	72, + + +	120, + + + −

[a] Died after the second collection of blood.

the administration of various drugs and chemicals as well as the effect of various conditions, physiologic and pathologic, upon this reaction.

I wish to express my sincere appreciation of the courtesies of Dr. Otto Schöbl, of the Bureau of Science, while this work was being done.

Thanks are due to Drs. Onofre Garcia and José Ramirez for their kindness in performing the Wassermann tests.

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TOTAL ALKALOIDS OF DATURA FASTUOSA LINNÆUS AND DATURA ALBA NEES FROM THE PHILIPPINES

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ONE TEXT FIGURE

In a recent paper on the pharmacognostical means for the identification of *Datura fastuosa* Linnæus and *D. alba* Nees, constituting the only representatives of *Datura* found in the Philippines, Santos (18) has quoted the medicinal and poisonous properties attributed to them by other investigators. No quantitative chemical analysis, however, of the alkaloidal principle in *D. fastuosa* as grown locally has been reported since Bacon (2) and Brill (3) used the white-flowered *Datura*, which is the common one growing wild throughout the Philippines and found in waste places in and around Manila. Considering the fact that these two species of *Datura* are widely distributed in neighboring countries, the writer believes that it would be of interest to undertake a comparative study of the amount of total alkaloids in the different parts of these two plants when cultivated under conditions approximately identical.

The active constituents of the plants under the genus *Datura* belong to the so-called "solanaceous alkaloids," which are chiefly characterized by their mydriatic action. According to Henry (10) this type of alkaloids includes the following:

1. Atropine and 2. Hyoscyamine, $C_{17}H_{23}O_3N$.
3. Nor-hyoscyamine, $C_{17}H_{21}O_3N$.
4. Meteloidine, $C_{13}H_{21}O_4N$.
5. Scopolamine (hyoscine), $C_{17}H_{21}O_4N$.
6. Apoatropine and 7. Belladonnine, $C_{17}H_{21}O_2N$.
8. Pseudo-hyoscyamine, $C_{17}H_{23}O_3N$.
9. Tropacocaine, $C_{15}H_{19}O_2N$.

In the species of *Datura* so far investigated, Browne, (4) Hesse, (11) Kircher, (13) Andrews, (1) Pyman and Reynolds, (16) Feldhaus, (8) Carr and Reynold, (5) and others have found the first five alkaloids above mentioned. The occurrence of more

than traces of atropine in solanaceous plants, however, is questioned by Henry,(10) who contends that probably it may be the resultant product of the isomerization of hyoscyamine by the agents used during the process of extraction.

Hesse,(11) who investigated the Chinese species of *Datura alba*, states that the flowers contain scopolamine, hyoscyamine, and atropine; while Andrews(1) and Schmidt,(19) who analyzed *D. metel*, which I believe is identical with the Philippine white-flowered *Datura*, have obtained only scopolamine and hyoscyamine from samples of leaves and seeds. Bacon,(2) on the other hand, working on *D. fastuosa* Linnæus var. *alba* Clarke from the Philippines (*D. alba* Nees), found the same active constituents detected by Hesse,(11) as indicated above.

With respect to *D. fastuosa* Linnæus, so far the only report is that of Andrews,(1) who examined chemically *D. fastuosa* var. *niger* from Assam, India. He claims that the twigs and the leaves contain scopolamine and hyoscyamine, while the roots and the fruits contain only scopolamine.

EXPERIMENTAL

Preparation of samples.—The material for this investigation was obtained from the plants cultivated in the botanical garden of the University of the Philippines. Samples of leaves, flowers, fruits, stems, and roots were collected at intervals during 1927 in order that any variation of the alkaloidal content traceable to the different stages of growth could be detected. In the case of the fruits, the seeds were separated from the corresponding pericarp and other inner parts of the fruit. It was found that the color and the hardness of the seeds offer a fairly good basis for determining the various stages of maturity of the fruit. The different samples of fruits selected are therefore characterized as follows:

1. *Very young fruit.*—This represents the very early stage of the fruit, just after the caducous corolla has fallen off where the seeds are soft and whitish.

2. *Young fruit.*—An immature fruit with yellowish white seeds which can easily be crushed between the fingers. The color is very prominent along the border of the seed.

3. *Fairly mature fruit.*—This stage is characterized by having seeds that are yellow in the center and brownish around the

edges. The seed coat is well developed and can be punctured by the needle with difficulty.

4. *Mature fruit.*—The mature fruits are distinguished from the younger ones by having seeds that are yellowish brown, somewhat shriveled and hard. The pericarp is rather soft, spongy in texture, and easily disintegrated.

All the samples of the various parts of the plant were air-dried and reduced to fine powder. Moisture determination for each sample was then carried out in order to express the percentage of total alkaloid based on moisture-free samples.

Methods of analysis.—There are several methods that can be used for the quantitative determination of the solanaceous alkaloids. Consequently, preliminary experiments were performed to compare the methods proposed by Keller as modified by Schmidt,(12) Dunstan and Ransom,(7) and Andrews;(1) these three being selected because they have been employed by many investigators.

Table 1 shows that Keller's method modified by Schmidt gives lower results than the two other methods. This difference may be due to the fact that in Keller's method as modified by Schmidt the percentage of alkaloids is expressed in terms of a single alkaloid since the determination is volumetric. This has its drawback when the sample contains more than one alkaloid. As Andrews's method is applicable to all samples irrespective of their source, it was adopted except that continuous percolation with hot alcohol was used in order to shorten the time consumed for the extraction. As a whole, the method used is as follows:

A 15- to 20-gram sample is placed in a Soxhlet extraction apparatus and the percolation with hot alcohol is continued until the percolate is colorless and does not leave more than traces of solid matter. The alcoholic extract is distilled under diminished pressure until nearly all the solvent is recovered. The semisolid residue is then treated with small quantities of warm water and, finally, with very dilute sulphuric acid to insure the complete extraction of the alkaloids. The combined aqueous acid liquid is then shaken with ether, made weakly alkaline with dilute ammonia, and shaken several times with chloroform to remove the alkaloids. The chloroform extract is washed with water in the separatory funnel, dried over anhydrous sodium sulphate, and then distilled under diminished pressure. The

total crude alkaloids thus obtained are dissolved in a small excess of very dilute sulphuric acid, and the acid solution is shaken with ether to remove traces of coloring matter and other impurities soluble in ether. This acidified aqueous liquid is then rendered slightly alkaline with dilute ammonia, and the alkaloids are extracted repeatedly, first by shaking with ether and then with chloroform. Both the ether and the chloroform extracts are washed with a little water, dried over fused anhydrous sodium sulphate, and after recovery of the solvents, the two fractions of alkaloids are dried in a vacuum desiccator and weighed. The combined weights of the two extracts give the "total alkaloids" contained in the sample.

TABLE 1.—*Comparison of analytical results for total alkaloids from the seeds of Datura alba Nees.*

Method.	Total alkaloids.		
	Sample 1.	Sample 2.	Mean.
	Per cent.	*Per cent.*	*Per cent.*
Keller modified by Schmidt	0.354	0.358	0.356
Dunstan and Ransom	0.373	0.370	0.372
Andrews	0.375	0.372	0.374

RESULTS

In Table 2, which represents the results of the investigation for the two plants, the various stages of the seeds and the pericarp correspond to the different ages of the fruit already described. The amount of alkaloids found in the pericarp also includes that from other inner parts of the fruit. Therefore, the total alkaloids present in a given stage of the fruit are computed by adding the percentages obtained from the seeds and the pericarp.

Leaves.—The leaves of *Datura fastuosa* contain slightly more alkaloids than those of *Datura alba.* In both plants the young leaves have a higher alkaloidal content than either the full-grown or the senescent leaves.

Flowers.—The results obtained from the flowers run parallel with those from the leaves, the young flower buds containing more alkaloids than either the unopened or the mature flowers; the flowers of *Datura alba,* however, contain more than those of *Datura fastuosa.*

Seeds.—As was to be expected, the mature seeds contain more alkaloids than the immature ones. This is true in both plants,

but as a whole the seeds of *Datura fastuosa,* except the very young ones, are higher in alkaloidal content than those of *Datura alba.*

Pericarp.—The results indicate that the pericarp of the very young fruit has more alkaloids than that of the other stages of the fruit analyzed. This is just the reverse of the condition found in the seed, for the high alkaloidal content of the mature seed is accompanied by the low percentage of the alkaloid in the corresponding pericarp, while the low percentage of total alkaloids in the very young seed is balanced by the high alkaloidal value of the very young pericarp. The pericarp of the fruit of *Datura fastuosa* yields more alkaloids than that of *Datura alba.*

Fruit.—The fruits of *Datura fastuosa* have a higher percentage of total alkaloids than the fruits of *Datura alba.* In both species, the very young and the mature fruits contain more alkaloids than the nearly mature fruits.

Stem and root.—There is only a very slight difference of total alkaloids found in the stems of *Datura fastuosa* and in those of *Datura alba.* However, the root of *Datura fastuosa* contains more alkaloids than that of *Datura alba.*

DISCUSSION OF RESULTS

The quantitative results, Table 2, show that the leaves, the seeds, the fruits, and the roots of *Datura fastuosa* have more alkaloids than the corresponding parts of *Datura alba,* while the flowers of the latter exhibit higher alkaloidal value than those of the former. The high percentage of alkaloids in the pericarp of the young fruit accompanied by the low amount of alkaloids in seeds of the same age, and the reverse condition in the mature fruit and seeds, indicates that during maturation of the fruit there is a migration of alkaloids from the pericarp to the seeds. There is only a very slight difference found in the alkaloidal content of the stems of the two species. When these results are compared with those of Table 3, it appears that the two species of *Datura* examined compare very favorably with the same or closely allied species of *Datura* grown in other countries. It can also be seen from Table 3 that my results for *Datura alba* lie within those obtained by Brill(3) for the same plant. The fluctuation of alkaloidal values for any given part of the plant as indicated in Brill's analysis is due to the fact that the samples were dried under different conditions since the object was to show the effects of drying on the alkaloidal content.

TABLE 2.—*Total alkaloids in various parts of Datura fastuosa Linnæus and D. alba Nees.*

Part of plant.	Sample 1.	Sample 2.	Mean.
DATURA FASTUOSA.			
	Per cent.	*Per cent.*	*Per cent.*
Young leaves	0.385	0.391	0.388
Full-grown leaves	0.221	0.222	0.221
Senescent leaves	0.212	0.209	0.210
Young flower buds	0.522	0.520	0.521
Unopened flowers	0.441	0.440	0.440
Mature flowers	0.285	0.282	0.283
Very young seeds	0.224	0.225	0.224
Young seeds	0.304	0.312	0.308
Nearly mature seeds	0.400	0.401	0.400
Mature seeds	0.453	0.433	0.443
Very young pericarp	0.406	0.415	0.410
Young pericarp	0.238	.....	0.238
Nearly mature pericarp	0.236	0.235	0.235
Mature pericarp	0.223	0.226	0.224
Very young fruit	0.630	0.640	0.635
Young fruit	0.542	0.550	0.546
Nearly mature fruit	0.636	0.636	0.636
Mature fruit	0.676	0.659	0.667
Young stem	0.217	0.220	0.218
Old stem	0.136	0.134	0.135
Root	0.252	0.244	0.248
DATURA ALBA.			
Young leaves	0.345	0.340	0.342
Full-grown leaves	0.191	0.190	0.190
Senescent leaves	0.183	0.180	0.182
Young flowers buds	0.660	0.661	0.660
Unopened flowers	0.513	0.512	0.512
Mature flowers	0.460	0.462	0.461
Very young seeds	0.225	0.229	0.227
Young seeds	0.250	0.252	0.251
Nearly mature seeds	0.369	0.370	0.369
Mature seeds	0.392	0.394	0.393
Very young pericarp	0.317	0.347	0.347
Young pericarp	0.130	0.131	0.132
Nearly mature pericarp	0.076	0.077	0.076
Mature pericarp	0.061	0.066	0.063
Very young fruit	0.572	0.576	0.574
Young fruit	0.380	0.382	0.381
Nearly mature fruit	0.415	0.447	0.446
Mature fruit	0.453	0.460	0.456
Young stem	0.217	0.215	0.216
Old stem	0.151	0.156	0.153
Root	0.139	0.140	0.139

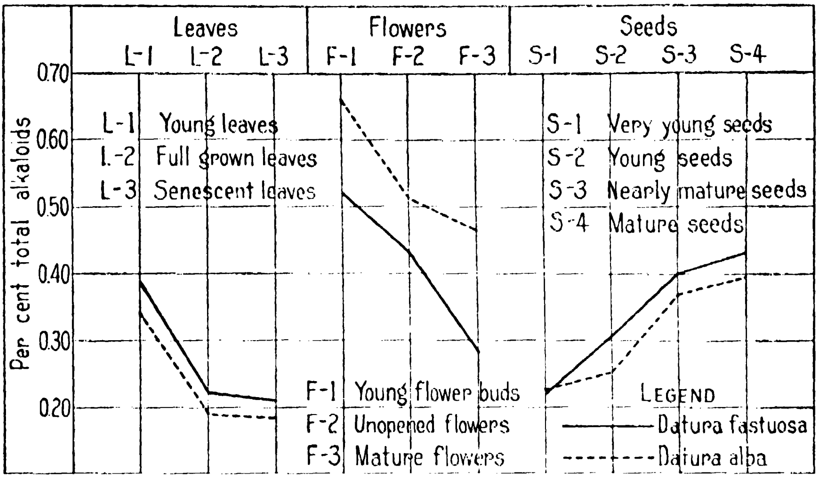

FIG. 1. Percentage of total alkaloids in some parts of *Datura fastuosa* and *Datura alba*.

TABLE 3.—*Alkaloidal content of Datura fastuosa, Datura alba, and Datura metel*[a] *as reported by other investigators.*

Species of *Datura*.	Part of plant.	Total alkaloids.	Investigator.
		Per cent.	
Datura fastuosa var. *niger*, from India.	Fruits	0.202	A. E. Andrews. (1)
	Leaves and branches	0.119	
	Roots	0.101	
Datura fastuosa var. *flor. alb. plen.*	Seeds	0.223	E. Schmidt. (19)
Datura metel	Leaves	0.25 0.55	A. Kircher. (13)
	Fruits	0.12	A. E. Andrews. (1)
	Seeds	0.23 -0.50	
	Roots	0.10 0.22	
Datura fastuosa Linn. var. *alba* Clarke, from the Philippines.	Leaves	0.210	R. F. Bacon. (2)
	Seeds	0.465	
	Wood and roots	0.170	
Datura alba Nees, from the Philippines.	Green leaves	0.210 0.406	H. C. Brill. (3)
	Stems	0.208 0.410	
	Flowers	0.205 0.489	
	Immature seeds	0.248	
	Mature seeds	0.393–0.589	
	Immature fruit	0.131-0.409	
	Nearly mature fruit	0.325	
	Mature fruit	0.175 0.380	
	Immature pods	0.081	
	Mature pods	0.076-0.327	F. Browne. (4)
Datura alba, from China	Flowers	0.485–0.550	O. Hesse. (11)

[a] *Datura metel* is included in this table since it is closely allied to, if not the same as, *Datura alba* Nees.

The consistent parallel variation observed in *Datura fastuosa* and *Datura alba* with respect to the alkaloidal constituent of their different parts varying in age, as shown in fig. 1, may have another significance on the mode of formation of alkaloids in plants. Thus, the presence of exceedingly high total alkaloids in the early stage of development of the leaves, the flowers, and the fruits suggests that alkaloidal synthesis in plants is undoubtedly related to the amount of nutrient materials present in the parts of the plant at different physiological periods; for taking into account the interrelationship of growth and vital activity, it seems very probable that the nature and the excess of food materials in different tissues and organs of the plant are influenced by the intensity of growth in the parts concerned. In this connection Gustafson's paper(9) concerning growth studies on fruits is of interest. It is, therefore, significant to note that at first glance the low percentage of total alkaloids in the leaves, the flowers, and the stems at their maturity seems to be not in accord with Pictet's hypothesis(15) on the formation of alkaloids containing a pyrrol ring or a pyridine nucleus. According to this theory, the mother substances of alkaloids are the nitrogenous decomposition products of more-complex substances, such as proteins and chlorophyll, as a result of metabolic processes. From this point of view, we should expect to find the reversed condition where the leaves, the flowers, and the fruits in their early stage of growth should have a much lower alkaloidal content than the mature ones. The writer's findings(14) on the nitrogen partition of the leaves of *Oenothera pratincola*, in connection with the problem on disease resistance, is directly concerned in this matter. It was found that in the leaves of *Oenothera pratincola* where there is chlorophyll degradation, the proportion of simpler nitrogenous compounds, like amino acids, acid amides, and ammonia, to the total nitrogen is higher than in full-grown leaves where chlorophyll degeneration is not observed. This is in keeping with the observation that protein synthesis in the leaves decreases in the autumn due to the degradation of the chloroplasts.(20) On the other hand, it is possible to reconcile the results obtained from the two *Datura* plants with Pictet's hyphothesis if we recall that Combes,(6) Rippel,(17) and others have confirmed the autumnal evacuation of nitrogen from the leaves to the branches. It may be then that the low alkaloidal content of the leaves and other parts when they are old is due to a considerable reduction of nitroge-

nous substances available for alkaloidal synthesis. As a whole this only means that purposeful experiments in this direction would yield results of lasting value in rendering possible a clear understanding of the physiological conditions governing the formation of alkaloids in plants.

SUMMARY AND CONCLUSIONS

1. This is a comparative study of the total alkaloids in various parts of *Datura fastuosa* Linnæus and *Datura alba* Nees from the Philippines. Incidentally, it also touches upon the variation of the alkaloidal content of the plant as exhibited by its various parts at different stages of growth.

2. Samples representing different ages of the leaves, the flowers, the fruits, and the stems were collected from plants of the two species of *Datura* grown side by side in the botanical garden of the University of the Philippines.

3. *Datura fastuosa* Linnæus contains more alkaloids in its leaves, seeds, fruits, and roots than does *Datura alba* Nees; the flowers of the latter have a higher percentage of total alkaloids than do those of the former.

4. As the fruit ripens there is a migration of alkaloids from the pericarp to the seeds.

5. In alkaloidal constituent *Datura fastuosa* Linnæus and *Datura alba* Nees from the Philippines compare very favorably with the same plants or closely allied species found in neighboring countries.

6. With the exception of the seeds, the young portions of the different parts of the plant yield more alkaloid than the corresponding mature portions.

7. The possible relation of the nutrient materials in the tissues and the organs of the plant at different physiological periods to the alkaloidal synthesis in plants is presented.

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ILLUSTRATION

TEXT FIGURE

FIG. 1. Chart showing the percentage of total alkaloids in some parts of *Datura alba* and of *Datura fastuosa*.

AN ASPHALTITE FROM THE PHILIPPINE ISLANDS

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During an investigation of the solid natural bitumens in Oregon [1] a specimen from the Philippine Islands was analyzed with results that furnish additional data upon this material, making possible the determination of its specific character, the material from which it was derived, and its origin. The samples studied were collected and its occurrence described [2] by Wallace E. Pratt, from the southwest slope of Mount Benao at the north end of Leyte Island.

The Leyte asphalt has been previously studied by Nelson [3] who summarizes his results as follows:

The natural solid bitumens occurring in Leyte Province have been classed as "pure bitumen" and bitumen-impregnated rock, and have been studied from a chemical and physical standpoint showing:

1. That Leyte pure bitumen differs from other mineralogical deposits of bitumens, such as ozocerite, montan wax, hatchettite, and scheererite, but is related to ozocerite. It is suggested that the pure bitumen of Leyte be termed leyteite.
2. That the chemical and physical properties of the bitumen found in the impregnated rock differ from those of the pure bitumen.
3. That the mineral aggregate of the bitumen-impregnated rock is principally limestone.
4. That the bitumen-impregnated rock would be suitable paving material, both in its natural state and after the introduction of fillers and fluxes.

CHEMICAL AND PHYSICAL PROPERTIES

The material occurs in large pure specimens. It is jet black, has conchoidal fracture and brilliant luster, and displays on paper and porcelain a dark brown streak. It is very brittle, so much so that when tested between the teeth it breaks up continuously into a fine black powder no fragments of which are maleable. When tested with a steel needle for penetration any pressure sufficient to mark it chips out small conchoidally fractured flakes.

[1] Hodge, E. T., Bull. Am. Assn. Petroleum Geologists 11 (April, 1927) No. 4.

[2] Philip. Journ. Sci. § A 10 (1915) 241.

[3] Philip. Journ. Sci. 22 (1923) 617.

TABLE 1.—*Analyses of grahamites and manjaks.*

	Grahamite.[a]	Grahamite.[b]	Sample S.[c]	Philippine sample.[d]	Manjak.[e]	Uintahite.[f]
Color	Jet black.	Jet black.	Jet black.	Jet black.	Jet black.	Black.
Luster	Brilliant	Brilliant to dull.	Brilliant	Brilliant	Brilliant	Brilliant.
Streak	Brown	Brown	Black	Brown	Brown	Brown.
Fracture	Conchoidal to hackly.	Conchoidal to hackly.	Conchoidal	Conchoidal	Conchoidal to hackly.	Conchoidal.
Specific gravity	1.11-1.145.	1.07-1.08	1.05-1.068	1.029-1.058	1.08-1.175.	1.01-171.
Hardness	2	2.5	2.0	2.5	2	2-2.5.
Electrical charge	Positive	Positive		Positive		Positive.
Softening point °C	175-315	330	150, imperfect	360	139-162	125.
Fusion point °C	Initial 200, cokes 175.	340	Intumesces		145-220	Initial 200 to 205.
Volatile at 165 °C per cent	0-1	0-1		0-1		1.0.
Fixed carbon do	30-56.4	23	26-62	55	24.7-31.7	10-35.
Ash do	30-56.1	Spongy coke	Delicate coke	47.5 coke	4.4-13.9	
Soluble in carbon bisulphide (CS_2) do	45-100	75	94.53	98.5	93.4-98.3	98-100.
Soluble in carbon tetrachloride (CCl_4) do	20-99	53		11.0		99.6-100.
Carbenes do	0.80.	22		87.5		0-2.0.
Paraffin			3.89.			
Soluble in benzine per cent	Partly	25		50.0, solution dark brown.	84.3-95.3	98-100.
Soluble in petroleum ether; boiling point, 40-60° C.; specific gravity, 633 do	Trace 50	0		5.0	22.2-36.4	20-60.
Soluble in ethyl alcohol do	0	0		0.00		0-54.6.
Soluble in chloroform do	90-100	70.5.		100.0		Partially.
Asphaltenes do		70.5				

With sulphuric acid (H_2SO_4)	Decomposes	Decomposes	Decomposes
With sodium hydroxide (NaOH)	0	0	0.00
Oder of gas			Petroleum

[a] According to Kirkpatrick, Redwood, Danby, Abraham, Dana, Smith, Scoth, Eldridge, and Hodge.
[b] Sample from Huntley Ranch near Clarno, Oregon, analysis by Hodge.
[c] Philippine material, analysis and data by Pratt.
[d] Philippine material, analysis by Hodge.
[e] According to Kirkpartick, Redword, Danby, Abraham, Eldridge, and Hodge.
[f] According to Kirkpatrick, Smith, Scott, Redwood, Danby, Abraham, Eldridge, and Hodge.

Fragments observed under the microscope are gray. When rubbed they are positively electrified; heated, they decrepitate, give off a gray gas with a faint petroleum odor, and small pieces finally melt down to a brilliant black fixed carbon. This button heated in a Bunsen flame intumesces and forms a gray bubble-filled slag. When heated in a crucible in a candle flame a sticky viscous liquid is obtained, which can be drawn out into long threads but does not stick to cold paper. The material melts at 360° C. to a jet black liquid, accompanied by a slight swelling and the production of a gray gas with a faint petroleum odor. Tested for fixed carbon and ash the material decrepitates and emits a gray gas with faint streaks of brown and a petroleum odor. Later the gas gets browner and has a faint ammonia smell. Finally only a gray gas is given off. The material does not melt down. It produces a brownish volatile stain of oil on the sides of the crucible. Fixed carbon is 55 per cent; greenish gray vesicular slag is 47.5 per cent.

Table 1 gives the properties of grahamite and manjak as tested and defined by many authorities.[4] In this table these analyses are compared with an analysis of grahamite from Oregon [5] and with the analyses of Philippine material. A comparison of these analyses with those of other native asphalts shows no similarity, and the comparison in this paper is, therefore, only with manjak and grahamite and with uintahite.

Richardson says that uintahite is derived from a nonparaffin oil and is not soluble in paraffin residues. The very small percentage of paraffin scales and the low solubility in benzine and, especially, in petroleum ether suggest that this sample has certain uintahite qualities. However, uintahite never has over 2 per cent of carbenes, and this sample contains 87.5 per cent. Grahamite, however, does not meet the above objection though it should not contain any paraffin scale. Grahamite in all re-

[4] Herbert Abraham, Asphalts and Allied Substances. New York, D. Van Nostrand Co. (1918).—Arthur Danby, Natural Rock Asphalts and Bitumens. London, Constable, Ltd. (1913).—G. H. Eldridge, The asphalt and bituminous rock deposits of the United States, U. S. Geol. Surv. Ann. Rept., Part 1 (1901) 22; The asphalt and bituminous rock deposits of the U. S., Bull. U. S. Geol. Surv. 213 (1902) 296–305; Formation of asphalt veins, Econ. Geol. 1 (1906) 437–444.—Sidney D. Kirkpatrick, Marketing the natural hydrocarbons, Eng. and Min. Journ. Press (February, 1925) 329.—Sir Boverton Redwood, Treatise on Petroleum. London, G. Griffin & Co. 1 (1922) 337.—Wilfred W. Scott, Standard Methods of Chemical Analysis. New York, D. Van Nostrand Co. (1917).

[5] Hodge, loc. cit.

ported samples never has a specific gravity below 1.14. In color, luster, streak, and fracture our Philippine sample is identical with grahamite. The high fixed carbon and, according to Richardson, the fact that grahamite may be derived from paraffin-base oils further favors this conclusion. In Table 1 the Philippine material is shown to agree with grahamite in all respects except specific gravity, melting point, and solubility in carbon tetrachloride (CCl_4). Thus it agrees more closely with grahamite than with uintahite. Manjak is closely related to grahamite, and in part agrees with the Philippine sample, especially in specific gravity. The Philippine material lies between manjak and grahamite (see Table 2). Further evidence in support of this conclusion is given below.

TABLE 2.—*To show that the Philippine sample is between manjak and grahamite.*

	Carbon bisulphide (CS_2).	Carbon tetrachloride (CCl_4).	Carbenes.	Petroleum ether.	Chloroform.	Asphaltenes.	Ash.
(a)	45-100	20-99	0-80	4-50	90-100	90-100	30-56
(b)	75	53	22	0	70.5	70.5	(g)
(c), (d)	96	11	87.5	5.0	100.0	100.0	47.5
(e)	93.98			22-36			4.13
(f)	98-100	99.6-100	0-2.0	20-60	(h)		

a–f See Table 1. g Spongy coke. h Partially.

The material analyzed by the author (sample d of Table 1) is the same as that reported by Pratt[6] (sample s). The sample was collected by Pratt and brought to the University of Oregon by Warren D. Smith, one time chief of the division of mines, Philippine Bureau of Science. The two analyses agree in all fundamental respects, indicating a high percentage of accuracy in both. Thus the fact that the sample of the first analysis intumesces suggests that it does not soften at 150° C. and that the volatile elements, if measured, would have been very low. The 55 per cent of the author's analysis approaches the average of 26 to 62 per cent of fixed carbons in Pratt's analysis. The discussion, therefore, in this paper will be based upon the latest analysis; that is, the author's.

GENESIS

The additional data herein presented confirm some and are at variance with other conclusions reached in Pratt's paper.

[6] Loc. cit.

Thus the high percentage of carbenes[7] confirms the view that the asphalts have been metamorphosed by heat. Pratt[8] says:

It is believed that the intrusions have been instrumental in driving the petroleum upward through the surrounding rocks. One of the observed petroleum seeps is on the contact of an apparently intrusive holocrystalline rock in the Vigo shale. All the petroleum and solid bitumen occurrences are near intrusions, and viscous or semiliquid bitumen is found in concretions and brecciated concretionlike bodies, the origin of which may reasonably be attributed to solutions given off by buried intrusions.

In this respect the asphalts of the Philippines are similar to those in Oregon and dissimilar to many occurrences in other parts of the world.

The low specific gravity and the presence of paraffin scales of the material lead Pratt[9] to state—

The Leyte natural bitumens are derived from a paraffin base petroleum. This fact at once distinguishes them from asphalt, as most commonly defined, which is derived either naturally or artificially from petroleum with an asphaltic base. The natural bitumen . . . was classified at the time of its discovery as gilsonite (or uintahite, another name for the same mineral) . . . Its specific gravity and its hardness are both less than the corresponding figures for gilsonite. Moreover, gilsonite, according to Richardson, . . . is derived from a nonparaffin oil and is not soluble in paraffin residues. All the Leyte bitumens are paraffin-bearing and are, therefore, not gilsonite according to Richardson. . . .

Grahamite, another natural bitumen, has something of the physical appearance. . . . But grahamite is heavier than any of the Leyte bitumens and has a higher proportion of fixed carbon.

Ozocerite is defined as a native paraffin, the physical appearance of which varies. Its color may be the same as that of some of the Leyte bitumens, its specific gravity is somewhat less, and it probably contains a higher average proportion of paraffin.

The difficulties stated above in attempting to determine the character of the Leyte material may be solved by a study of the new analysis. A low specific gravity in natural bitumen is usually accompanied by a decrease in ash and an increase in petrolenes.[10] The ash in the Leyte sample, however, is rather high, which assuming the sample to be pure and free of contaminated mineral fragments is due to oxidized hydrocarbons. The high ash, therefore, might be explained by its long surface

[7] The term "carbene" is employed for those constituents soluble in carbon bisulphide but not soluble in carbon tetrachloride. Carbenes are especially common in grahamite, native asphalts, and asphaltites.

[8] Philip. Journ. Sci. § A 10 (1915) 253.

[9] Op. cit. 263.

[10] Petrolenes are the volatile hydrocarbons of petroleum ether, ethyl ether, or acetone.

exposure in a tropical country expedited by the heat of adjacent igneous intrusions.

The next question now becomes, What material has been oxidized to produce the high ash? We note that the low specific gravity is not accompanied by high petrolenes. These are close to the minimum for grahamite and very low for manjak. If the original components had undergone much inspissation or molecular condensation there should be more than 5 per cent of petrolenes present. The low petrolenes might be interpreted to indicate that the original material was rich in grahamite and low in manjak. This conclusion is not in harmony with other evidence. It were better to decide that the compounds giving rise to the high ash were not those rich in petrolenes but asphaltenes [11] which constitute 100 per cent. The high fusibility shows that these asphaltenes have been altered. Here we have an explanation of the high ash.

The Leyte specimen is apparently a substance that has been oxidized by exposure and metamorphosed by heat without any great molecular condensation of the petrolenes or asphaltenes, because the material is insoluble in carbon bisulphide. The percentage of fixed carbon plus ash, which is very high for most grahamites or manjaks, is not due to pyrobitumens or asphaltic pyrobitumens.

All possible sources of the high ash and fixed carbon have now been considered, leaving only oxidation and thermal metamorphism as a possible explanation. The material has been altered in such a way as not to increase the specific gravity, but greatly to increase the melting point and the percentage of fixed carbon. The process may have been favored by the slow seepage of the Leyte asphalts to the surface.

Richardson states than when crude petroleum, which contains a high percentage of hydrogen, and therefore simple hydrocarbons, is subjected to heat and pressure under favorable conditions, a large volume of gaseous hydrogen is eliminated, resulting in the conversion of the hydrocarbons into compounds more complex both chemically and physically. Colloidal clay accelerates the process by acting as a catalyzer. The petroleum is converted into asphalt by emulsification with clay, sand, and water by means of natural gas at high pressure. Nutting [12] has found that petroleum and water are slightly soluble in each

[11] Asphaltenes (Danby) or malthenes (Richardson) are those parts dissolved by boiling turpentine or chloroform.

[12] Nutting, P. G., Econ. Geol. 21 (1926) 234-242.

other and both are strongly absorbed by silica. In the presence of this catalyzer the oil in the presence of water will not only be driven out of sands but will undergo a chemical change. This change may result in conversion into compounds of high fusibility but of low specific gravity. As the results of studies of the famous pitch lake in Trinidad, British West Indies, he concludes that the petroleum is converted into asphalt by emulsification with clay, sand, and water by means of natural gas at high pressure. Maltha and other soft asphalts, hard asphalt, the asphaltites (gilsonite and grahamite), the asphaltic pyrobitumens (elaterite and wurtzilite), and asphaltic pyrobituminous shales are probably successive stages in the metamorphosis of asphaltic petroleum. If the petroleum is of paraffin base, ozokerite and other mineral waxes are sometimes formed.

Finally, the evidence does not point to a paraffin-base oil as the source of the material. Richardson says that grahamite is due to a condensation of paraffin oils and so differs from uintahite and manjak, which are formed by unsaturated hydrocarbons. The formation of asphalt, related bitumens, and pyrobitumens presupposes the existence of petroleum containing asphaltic hydrocarbons, and that of ozokerite presupposes the existence of paraffinaceous petroleum.[13]

Pratt found 3.89 per cent of paraffin in the Leyte material. This small amount is in agreement with the 5 per cent of petrolenes. Both these facts indicate that some grahamite is present but only in a small amount, perhaps to 10 per cent. In the main the material is manjak. Since the time of the Pratt paper our views have changed regarding the bases of petroleum. Thus, at present, an asphaltic base means a large amount of sulphur, and a paraffin base a low percentage of sulphur. In this paper "asphaltic" is used in the sense of being rich in cyclic compounds.

OTHER OCCURRENCES

Grahamites and manjaks are widely distributed. Grahamite has been found to be more widely distributed in the United States than most of the natural asphaltic hydrocarbons, notably in Richie County, West Virginia, and Payette and Stephens Counties, Oklahoma. The largest known vein, 19 to 25 feet wide and more than a mile long, is in Jackford Valley, near Tuskahoma, Oklahoma. Unlike uintahite, it is found in several foreign countries; the deposits in Cuba, Mexico, and Trinidad Island are the most important. Other occurrences are in Utah,

[13] Mineral Resources of the U. S. pt. 2 (1918) 467.

Colorado, and Oregon. The grahamite vein in West Virginia occupies a vertical fissure in the Waynesburg sandstone and adjoining beds above and below, all in the upper Carboniferous.[14]

The grahamite of Middle Park, Colorado, occurs in a vein that is considered to have been filled with liquid or viscous bitumen derived from adjacent or nearby strata.

Grahamite characteristically contains a large proportion of inorganic impurities. Ladoo [15] says that "the Oklahoma deposit has been worked extensively and many thousand tons removed." Grahamite finds its chief use in the roofing industry, since when mixed with asphaltic fluxes it forms a rubbery, elastic covering very satisfactory for this purpose. With other bitumens it yields varnishes, rubber substitute for waterproofing, and compounding materials for electrical insulation. No commercial production of grahamite has been reported since 1924.[16]

Manjak [17] is a term that originated on Barbados Island, where it was applied to a high-grade black bitumen, which breaks with a conchoidal fracture, exposing a bright, lustrous surface. Barbados manjak has a specific gravity of 1.10, a hardness of 2, and a fusion point of 320 to 430 F. It contains a varying amount of mineral matter and about 90 per cent of carbon, of which 25 to 30 per cent is fixed carbon. The essential characteristics of Barbados manjak are given in Table 3. Trinidad manjak differs principally from the Barbados in that it has a higher specific gravity (1.175) and a lower total carbon content. Both are exported to the United States, but the Barbados variety commands a much higher price. The following paragraphs and Table 3 are from Kirkpatrick's article, cited above.

Manjak finds its principal application in paints and varnishes, in which it is usually mixed with mineral oils. These are used as protective coverings on pipe lines, structural steel work, and machinery. An interesting application of some promise is as a pipe cement and packing at the joints of rotary drill pipe, especially in the oil fields.

According to recent quotations (January, 1925) Barbados manjak in one to five-ton lots sold in New York for the following prices: Grade A, 6c. per pound; Grade AA, fine 8c. per pound; and Grade C, lump, 12c. per pound.

[14] Reports of Department of Interior, Geological Survey, House Documents 28: 228–229; 327–328.

[15] U. S. Bur. Mines, Report of Investigations (May, 1920).

[16] Hopkins, G. R., Asphalt and Related Bitumens in 1926, Dept. of Commerce, Bureau of Mines publication.

[17] Kirkpatrick, S. D., Engineering and Mining Journal-Press **119** (1925) **331**.

TABLE 3.—*Characteristics of Barbados manjak.*

		Grade—		
		A	AA	C
Total carbonaceous matter	per cent	86.10	95.58	98.37
Mineral matter (ash)	do	13.90	4.42	1.63
Volatile matter on ignition	do	56.90	63.85	68.47
Fixed carbon on ignition	do	29.20	31.73	29.90
Solubility in petroleum ether	do	29.75	33.45	36.37
Solubility in 90 per cent benzol	do	84.30	94.48	92.23
Solubility in carbon disulphite	do	93.40	94.95	95.76
Specific gravity		1.116	1.153	1.128
Softening point (Kraemer and Sarnow)	°C	162	160	139
Melting point (Kraemer and Sarnow)	°C	180	177	145

THE BUMBLEBEES OF THE PHILIPPINE ISLANDS (BREMIDÆ: HYMENOPTERA)

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ONE PLATE

In 1925, in the Philippine Journal of Science, I published a paper on the bumblebees of the Philippine Islands giving a summary of the systematic knowledge of the species and varieties and certain other information. The accumulation of additional material and exact information regarding the structural characters of the type (worker) of *Bremus irisanensis* (Cockerell) makes the publication of some supplementary notes and new keys highly desirable.

For additional material I am greatly indebted to Dr. H. Hedicke, of Berlin, Germany, who gratiously sent me specimens of this genus from the Philippine Islands (including the male type of *B. imuganensis* Hedicke) from his collection. Several specimens were submitted, also, by the Hawaiian Sugar Planters' Association. To Dr. James Waterston, of the British Museum, and Mr. O. W. Richards, of Oxford, England, I am much indebted for critical notes regarding the structural characters of the worker type of *B. irisanensis* (Cockerell) and for comparing with the type two specimens submitted to them.

For the sake of convenience and clarity I have arranged my remarks in this paper under the following headings: Synonymy, descriptions, keys to species and castes, tabulation of descriptions, and bibliography.

SYNONYMY

BREMUS (HORTOBOMBUS) IRISANENSIS (Cockerell).

Bombus irisanensis COCKERELL, Ann. & Mag. Nat. Hist. VIII 5 (1910) 416, ☿.

Bombus irisanensis COCKERELL, Philip. Journ. Sci. 14 (1919) 81.

Bremus irisanensis FRISON, Philip. Journ. Sci. 27 1925) 116, ♀ [= ☿ not ♀].

Bremus irisanensis HEDICKE, Deutsch. Ent. Zeitschr. (1926) 421, ♀, ☿, and ♂.

The study of additional material soon after the appearance of my first paper (1925) on the bumblebees of the Philippine Islands revealed that two species of these large social bees were masquerading as a single species under the guise of similar colors and a similar color pattern. This was evident, likewise, from the illuminating remarks published by Hedicke in a recent paper (1926). Correspondence with Doctor Hedicke and the study of his specimens removed all doubt about the matter, but did not definitely establish which of the two species was entitled to the name of *irisanensis* (Cockerell).

As mentioned in the introduction of this paper, Doctor Waterston and Mr. Richards, of England, very kindly answered certain questions for me regarding the structural characters of the worker type of *B. irisanensis* (Cockerell). It is evident from their report that the type of *B. irisanensis* has a long malar space and that the metatarsus of the middle leg at its apical outer angle has a sharp spinelike projection. This is conclusive evidence that this species belongs to the section *Odontobombus* Kruger. A study of a male of this species establishes, also, that it belongs to the subgenus *Hortobombus* Vogt.

A study of a male, a queen, and workers of the species studied and recorded by Hedicke (1926) has established that his specimens are the true *irisanensis* as listed by him. Also, the females redescribed in more detail by myself (1925) are *irisanensis* as originally listed. They are, however, workers instead of queens. This is evident from a study of a queen submitted by Doctor Hedicke, which as he (1926) states measures 27 millimeters in length and has a spread of wings of 54 millimeters.

Since the male and the queen have never been described in detail, this is done in another part of this paper.

BREMUS (PRATOBOMBUS) BAGUIONENSIS (Cockerell).

Bombus irisanensis var. *baguionensis* COCKERELL, Philip. Journ. Sci. **16** (1920) 631, ☿.

Bremus irisanensis var. *baguionensis* FRISON, Philip. Journ. Sci. **27** (1925) 118, ♂.

The determination of the sectional and the subgeneric status of the true *irisanensis* (Cockerell) has made it necessary that the form described as *baguionensis* (Cockerell) be recognized as a valid species instead of a color variety. Specimens of *baguionensis* in my collection from the locality of the type and compared with the worker type by C. F. Baker have been available for this study, and the results have led to this conclusion.

Bremus baguionensis is a smaller species, witth a malar space of moderate length, and in the females the metatarsus of the middle leg at its apical outer angle does not have a sharp spine-like projection. The genitalia of the male (Frison, 1925) affords final and conclusive proof that *baguionensis* belongs to the section *Anodontobombus* Krüger and to the subgenus *Pratobombus* Vogt.

BREMUS (PRATOBOMBUS) BAGUIONENSIS var. IMUGANENSIS (Hedicke).

Bombus imuganensis HEDICKE, Deutsch. Ent. Zeitschr. (1926) 422, ♂.
Bombus irisanensis FRISON, Philip. Journ. Sci. 17 (1925) 116, ♂.

The male described as *imuganensis* by Hedicke (1926) does not differ structurally from the male of *baguionensis*, as evidenced by the statement of Hedicke that "stimmt der Kopulationsapparat völlig mit Frison's Abbildung überein." Furthermore, a critical study of the type submitted by Hedicke bears out this contention.

In color *imuganensis* is essentially like *baguionensis*, except that the dorsum of the thorax is somewhat darker because of a slight admixture of dark hairs, and the fifth and sixth dorsal abdominal segments are black. Since the typical *baguionensis* has light ochraceous or light ferruginous pubescence on the fifth and sixth dorsal abdominal segments, the name *imuganensis* may be preserved as a varietal name for a black-tailed color variety of the species *baguionensis*.

Females referable to the color variety *imuganensis* Hedicke exist, as proved by the presence of such a female in my collection. Since the queen of *baguionensis* or its variety *imuganensis* has not been described, and many of the structural characters of the species were omitted in the original description, more-detailed descriptions of them are presented.

DESCRIPTIONS

Since the castes of bumblebees (queen, worker, and male) often differ in color from one another, as well as always in structure in the two sexes, I believe that detailed descriptions of them in addition to a detailed description of the type or holotype (whatever caste that may be) are advisable. Accordingly, under this heading I present the descriptions of several forms that have never been described. The preservation of actual single specimens of specimens used in preparing such descriptions is highly desirable and is aided by assigning to such specimens the frequently used terms "allotype" and "mor-

photype." The term "allotype" is here used to designate the first described specimen of opposite sex to the type, whatever sex that may be, of a previously known species. The term "morphotype" is used for the second form of a dimorphic sex, which in the case of the bumblebees is always of the female sex (queen or worker). Naturally, here again the designation is applied solely to a specimen used in preparing the first description of the undescribed caste. Such designations as allotype and morphotype have no nomenclatorial significance unless they happen also to be at the same time paratypes. Even if they happen to be true paratypes, as is not the case with any of those designated in this paper, they have no more nomenclatorial significance than any other paratype.

BREMUS MEARNSI var. BAKERI (Cockerell).

Worker.—Pubescence on head entirely dark. Labrum with tuberclelike areas, which are prominent, shagreened on inner margins and shiny on outer margins, with a few large punctures on prominent elevated ridge, the space between tubercles nearly equal to the length of the second flagellar segment; shelflike projection broad, rugose. Mandibles distinctly three-toothed with slight indications of a fourth tooth at lower apical angles; setæ on distal portion of mandible between the raised longitudinal ridges very short, dense, golden in color. Clypeus smooth, shiny, with a few small punctures on its disk, and large punctures mixed with smaller ones on the lateral, dorsal, and anterior portions. Malar space slightly longer than its width at articulation of mandible (from precoila to postcoila), about one-half as long as the greatest width of, and one-fifth as long as, the compound eye; smooth, shining, but feebly punctate. Ocelli situated just above the narrowest part of the vertex; each lateral ocellus about its diameter distant from the median ocellus; area between lateral ocelli and median margin of compound eyes polished, almost impunctate. Flagellum slightly more than twice as long as the scape; third flagellar segment longer than the fifth, the fifth slightly longer than the fourth.

Dorsum and sides of thorax entirely with dark pubescence; center of disk smooth and impunctate.

Abdomen with the first four dorsal abdominal segments covered almost entirely with moderately long dark pubescence; that on fifth and sixth apical segments yellowish brown. Venter with light yellowish brown pubescence. Hypopygium without a median carina.

Legs with cuticle reddish brown; pubescence on trochanters light, on femora dark, on tibiæ and tarsi bright golden color. Metabasitarsus distinctly arcuate and outer surface nearly flat. Distal end of mesobasitarsus without a pronounced apical projection. Corbiculæ slightly shagreened.

Proximal portion of the wings yellowish, distal portion distinctly suffused, nervures prominent.

Length, 14 millimeters; spread of forewings, 31 millimeters; width of abdomen at second segment, 8 millimeters.

Morphotypic worker, Mount Canlaon, Occidental Negros, Philippine Islands, August 29, 1921, 5,000 feet elevation; collected by F. X. Williams. Deposited in the collection of the author. Another worker with the same data deposited in the collection of the Hawaiian Sugar Planters' Association. In general, the workers of this variety are replicas of the queens.

BREMUS IRISANENSIS (Cockerell).

Male.—Clypeus densely covered with long yellowish pubescence; that on occipital orbits, surrounding bases of antennæ and occiput, a black color. Malar much longer than its width at articulation of mandible between precoila and postcoila, about three-fourths as long as greatest width of and about one-third as long as length of compound eye. Ocelli very small, situated above narrowest part of the vertex, about their diameter removed from median ocellus. Space between each lateral ocellus and compound eyes smooth and shiny on mesal half and with large scattered punctures on outer half. Flagellum about four times as long as scape; third and fourth segments about equal in length, fifth much longer than either, middle flagellar segments distinctly arcuate.

Dorsum and upper anterior corners of pleura of thorax entirely black; mesopleura with yellow or fulvous-yellow pubescence. A narrow elongate impunctate area, somewhat shagreened, on disk of mesonotum.

Abdomen with yellow or fulvous-yellow pubescence on the first two dorsal abdominal segments, pubescence on the remaining segments black. Venter with blackish pubescence.

Sagittæ without a cyclelike hook at end; head widened and toothed on outer margin, terminating in a point; shaft with a pronounced downward directed tooth in middle of its length on lower margin. Uncus narrow and pointed at apex. Squama large, with a curved hooklike process on its mesal posterior margin. Vosellæ extending well beyond squamæ and considerably

inwardly; apex with a small hook directed outwardly. Dorsal view of genitalia shown in fig. 1. Inner and outer spathæ shown, respectively, in figs. 2 and 3.

Legs with cuticle blackish, with mostly black hairs except upon tarsal segments which are more golden brown. Hind tibiæ on outer surface convex, with numerous setæ bearing punctures. Metatarsus of middle leg at apical outer angle with a pronounced, sharp, spinelike projection. Metatarsus of hind leg concave, with hind margin somewhat arcuate; three and one-half times as long as greatest width.

Wings fuliginous throughout.

Length, 22 millimeters; spread of forewings, 47 millimeters; width of abdomen at second segment, 10 millimeters.

Allotypic male, Imugan, Luzon, Philippine Islands, 1923. Deposited in the collection of the author by permission of Doctor Hedicke, who first recorded but did not fully describe this male.

Queen.—Similar, except in size, in structural details, and in color characters, to the workers as redescribed by Frison (1925, pp. 116–117). In addition to that description the narrow elongate bare area on disk of mesonotum is somewhat shagreened; metatarsus of middle leg and hind legs at apical outer angles with pronounced, sharp, spinelike projections.

Length, 27 millimeters; spread of wings, 54 millimeters; width of abdomen at second segment, 11 millimeters.

Morphotypic queen, Imugan, Luzon, Philippine Islands, 1923. Deposited in the collection of the author by permission of Doctor Hedicke, who first recorded but did not fully describe this queen.

The additional characters here recorded for the queen of the typical *irisanensis* (Cockerell) are also found on the workers. In a previous paper in the Philippine Journal of Science (1925) I described two rather large females of *Bremus irisanensis* (Cockerell) and designated them as morphotypic queens, thinking them to be the queens of this species. The study of material submitted by Doctor Hedicke proves them to be large workers, and since these specimens have no nomenclatorial status they are to be disregarded as morphotypical specimens. The true queen is here described from a specimen which was a part of the original Hedicke material (1926; first authentic report of queen and male) and is now designated as the true morphotype. Likewise, the male from the same material is designated as the allotype.

BREMUS BAGUIONENSIS var. IMUGANENSIS (Hedicke).

Queen.—Face, occipital orbits, and occiput with black hairs. Labrum with tuberclelike areas moderately separated, lateral portions smooth and shiny, mesal portions with some large punctures and somewhat shagreened; shelflike projection rugose, about one-half as long as width of labrum, with its anterior margin strongly cresentic. Mandible three-toothed, with but a slight suggestion of a fourth tooth at lower apical angle. Clypeus with a smooth shining mesal area, punctate on lateral and upper portions. Malar space about as long as its width at articulation with mandible; about one-half as long as greatest width of and slightly less than one-fourth length of compound eye. Ocelli large, situated just above narrowest part of the vertex, just below supraorbital line; lateral ocelli slightly closer to the inner margin of the eyes than to one another; area directly lateral of each lateral ocellus mostly impunctate and shining, a few small punctures near margin of eye. Flagellum slightly less than twice as long as the scape; third antennal segment much longer than fifth, the fifth longer than the fourth.

Dorsum of thorax and upper anterior corners of pleura with black pubescence, that on remaining areas of pleura dark yellowish; a narrow, elongate, impunctate, smooth and shiny area in the center of disk.

Abdomen with dark yellowish pubescence on the first two dorsal abdominal segments, pubescence on remaining segments black. Venter with dark pubescence. Hypopygium without a median carina.

Legs with cuticle mostly black, but in places inclined to be reddish, particularly on hind corbiculæ and tibiæ. Corbicular fringes dark. Apical outer angle of metatarsus of middle leg with a pronounced, sharp, spinelike projection.

Proximal portion of the wings yellowish, distal portion distinctly suffused, nervures prominent.

Length, 18 millimeters; spread of forewings, 39 millimeters; width of abdomen at second segment, 8 millimeters.

Morphotypic queen, Mount Banahao, Tayabas Province, Luzon, Philippine Islands, April 29, 1921, 4,000 feet elevation; collected by F. X. Williams. Deposited in the collection of the author.

Superficially identical in coloration with *irisanensis* (Cockerell), but differs markedly in structural characters as pointed out in the key to females.

Keys to the Philippine species and varieties of Bremus.

QUEENS AND WORKERS (FEMALES)

1. Metatarsus of middle leg at apical outer angle with a pronounced, sharp, spinelike projection; ocelli small, each lateral ocellus nearly twice as far removed from median ocellus as its diameter; outer half of area between lateral ocelli and median margin of compound eyes strongly punctate; first and second dorsal adbominal segments with yellow or fulvous-yellow pubescence; very large queen (26 millimeters in length) and workers (15 to 20 millimeters in length).
Bremus (*Hortobombus*) *irisanensis* (Cockerell).

   Metatarsus of middle leg at apical outer angle without a pronounced, sharp, spinelike projection; ocelli large, each lateral ocellus less or not more than its diameter removed from median ocellus; outer half of area between lateral ocelli and median margin of compound eyes smooth, shiny, with but few small punctures; small queens (19 millimeters in length) and workers (11 to 13 millimeters in length) .... 2.

2. First and second dorsal abdominal segments with black or chocolate-brown pubescence .... 3.

   First and second dorsal abdominal segments with yellow or fulvous-yellow pubescence .... 4.

3. Pubescence of the thorax and basal, dorsal, abdominal segments nearly black; only the last two apical, dorsal, abdominal segments entirely reddish fulvous .... *Bremus mearnsi* var. *bakeri* (Cockerell).

   Pubescence of the thorax and basal, dorsal, abdominal segments chocolate brown; last three apical, dorsal, abdominal segments entirely or nearly yellowish brown or fulvous .... *Bremus mearnsi* (Ashmead).

4. Apical segments entirely or mostly black.
Bremus (*Pratombombus*) *baguionensis* var. *imuganensis* (Hedicke).

   Apical segments with yellowish or golden brown pubescence.
Bremus (*Pratobombus*) *baguionensis* (Cockerell).

MALES

[The male of *Bremus mearnsi*, or of its variety *bakeri*, is not known.]

1. Metatarsus of middle leg at apical outer angle with a pronounced, sharp, spinelike projection; hind tibiæ on outer surface without a large more or less bare, impunctate area on middle portion; head of shafts of sagittæ of genitalia without a cyclelike hook.
Bremus (*Hortobombus*) *irisanensis* (Cockerell).

   Metatarsus of middle leg at apical outer angle without a pronounced, sharp, spinelike projection; hind tibiæ on outer surface with a more or less bare, shiny, impunctate area on middle portion; head of shafts of sagittæ of genitalia with a cyclelike hook (*Pratobombus*) .... 2.

2. Apical dorsal segments of abdomen with a considerable amount of yellow or fulvous-yellow pubescence.
Bremus baguionensis (Cockerell).

   Apical dorsal segments of abdomen entirely dark or with fulvous-yellow pubescence restricted to last segment.
Bremus baguionensis var. *imuganensis* (Hedicke).

TABULATION OF CASTE DESCRIPTIONS OF SPECIES AND VARIETIES

Bremus mearnsi (Ashmead); type, worker (1905); collection United States National Museum.

Bremus mearnsi (Ashmead); morphotype, queen (Frison, 1925); collection United States National Museum.

Bremus mearnsi var. *bakeri* (Cockerell); queen (1920); collection Baker 11839.

Bremus mearnsi var. *bakeri* (Cockerell); morphotype, worker (Frison, 1928); collection Frison.

Bremus irisanensis (Cockerell); type, worker (1910) collection British Museum.

Bremus irisanensis (Cockerell); allotype, male (Frison, 1928); collection Frison.

Bremus irisanensis (Cockerell); morphotype, queen (Frison, 1928); collection Frison.

Bremus baguionensis (Cockerell); type, worker (1920); collection Baker 11841.

Bremus baguionensis (Cockerell); allotype, male (Frison, 1925); collection Frison.

Bremus baguionensis var. *imuganensis* (Hedicke); type, male (1926); collection Frison.

Bremus baguionensis var. *imuganensis* (Hedicke); morphotype, queen (Frison, 1928); collection Frison.

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ILLUSTRATION

PLATE 1. BREMUS IRISANENSIS (COCKERELL)

FIG. 1. Male genitalia.

2. Inner spatha.

3. Outer spatha.

1

2

3

PLATE 1. BREMUS IRISANENSIS (COCKERELL).

NEW PHILIPPINE SHIPWORMS

By P. B. Sivickis

Of the University of the Philippines, Manila

THREE PLATES

Bartsch (1927) lists sixteen species of shipworms from the Philippines, four of which may be considered as of doubtful validity. In this paper I present fifteen species of these animals, none of which has been described before. Bartsch's specimens were collected from the deeper waters, while mine came from the shore, from floating wood, or from sand. None of them came from water deeper than one meter.

The classification here adapted is that of Bartsch as given in his monographs. It is based almost entirely on the shells and the pallets. As pointed out by Miller (1922) classification based on either shell or pallets alone is of doubtful value and can be resorted to only in cases of absolute necessity. For this reason I have left incomplete specimens for further study when more material may come to hand. The nomenclature of parts adopted by Bartsch and by Miller is used.

All three genera of teredos are represented in the Philippines. Future study may necessitate the creation of new genera. I am inclined to think that the shell described by Bartsch in *Eoteredo philippinensis* belongs to *Bactronophorus* and that the new generic name will not be applicable. On the other hand, it is possible that *Teredo hydei* and *T. apendiculata*, described in this paper, should be referred to a new genus. I admire Bartsch's creation of subgenera, but I cannot follow his example in this respect. I think that this group of animals is much larger than is generally supposed, at least in the Philippines, and our knowledge is still inadequate for the division into subgenera.

The type specimens of the species described herein have been deposited in the Bureau of Science, Manila.

Genus BANKIA Gray, 1840

The blade of the pallet consists of a series of cones which are free at their distal end. The cones may fit very closely

into each other or they may be open and end in spiny projections.

BANKIA TRIANGULARIS sp. nov. Plate 1, fig. 1.

Shell large and triangular; rather thin for its size. Sinus is in the form of an arc of an ellipse and runs along the dorsal border of the anterior part. Anterior part considerably wider than high (5 : 9). Both anterior and anterior median parts very finely ridged. The ridges are so fine that it is very difficult to count them even if magnified with a hand lens. A little over three hundred ridges were counted. Anterior median part very wide, about 1.5 times the rest of the median and the auricle combined. Middle median slightly declined posteriorly. Posterior median very narrow, just a little wider than middle median. Auricle very small or lacking. Line of junction between right and left shells very long, of the same length as distance from umbone to knob. The shell has a general appearance of a right triangle.

Inside of shell bluish white. The shelf is entirely at the rim of the posterior median until it reaches the auricle; from this point it merges with the auricle. The blade springs from the posterior median and the ventral border of the shell; usually it is small but in some cases about one-fourth of it may reach the anterior median part.

Pallets of medium size, with very closely packed cones. The composite nature of the pallets is seen best from the outer surface.

The specimens were collected in Cebu by R. S. Filoteo.

BANKIA ORYZAFORMIS sp. nov. Plate 1, fig. 2.

Shell small, thin, transparent, and light blue. The anterior part spreads fanlike. Width and height of anterior part about equal. Ridges on anterior median finer than those of anterior part, but in spite of inequality the number is about the same. Middle median narrow. Posterior median about equal to width of middle and posterior medians combined. Irregular growth lines well marked. Auricle rather small, at a slight angle with posterior median. In the inside of the shell the junction between the auricle and the posterior part is marked by a strong shelf. Blade short and broad; it springs from the rim of the callus. Knob prominent.

Pallets of loose cone-in-cone type. Margins of cones entirely free and smooth. Peduncle thin and even in thickness throughout, except near the blade where it becomes abruptly thickened.

The specimens were found in a piece of wood (*Xylocarpus* sp.) exposed during low tide at Puerto Princesa, Palawan.

BANKIA QUADRANGULARIS sp. nov. Plate 1, fig. 3.

Shell above medium in size and thickness. The usual callus extends in a straight line along the rim of the anterior part. This gives it the shape of a more or less irregular quadrangle. Anterior part wider than high (7 : 5). Ridges fine but distinct; about ninety can be counted. Denticles very fine. Anterior median slightly wider than middle and posterior medians combined. Ridges of anterior median similar to those of anterior part; they coördinate at the junction of the two parts. Middle median part narrow, but well marked on both sides. Posterior median well arched and merges into a small auricle.

Inside of shell rather smooth. Shelf well marked. The blade arises from underside of rim of umbone and passes almost parallel to shelf. Knob prominent.

Pallets rather stout with cones very close together. Peduncle peglike and about as long as blade.

Specimens were obtained from stumps that had been under water for about a year, at Dalahican, Cavite, Luzon.

BANKIA TENUIS sp. nov. Plate 1, fig. 4.

Shell of medium size, subglobular, and thin. Anterior part fan-shaped and almost twice as wide as high. Callous rim almost straight. Ridges fine but far apart; about thirty can be counted. Anterior median rather narrow. No correlation between ridges of anterior and anterior median parts. In the latter the ridges are about twice as close as in the former, permitting irregular intercallation of the ridges of two regions. Middle median part, as usual in these animals, rather narrow and slightly sunken. Posterior median about 1.5 times as wide as anterior median part. Growth lines of middle and posterior parts well marked, widely separated, and as usual run in the opposite direction to those in anterior median. Auricle large and distinctly separated from posterior median part. Sculpture inside of the shell clear. Shelf rather low; blade springs from rim of the underside of umbone, is short, and runs twisted at an angle parallel to the shell. Knob prominent.

Pallets long and white, with cones closely approximating each other. Free margins of cones clearly pectinate or comblike; the pectination clearer in old specimens.

Collected by R. S. Filoteo, from the Cebu region.

BANKIA GLOBOSA sp. nov. Plate 1, fig. 5.

Shell small, subglobular, and thin. Callous growth along the dorsal anterior edge of anterior part runs in a straight line. Anterior part well developed. Ridges distinctly denticulate and rather coarse; over thirty can be counted. Anterior median distinctly separated from anterior. Ridges of the two regions poorly articulate with each other; those of anterior median lying closer to each other. Denticles more clearly marked in anterior median than in anterior part. Middle median narrow and marked with fine lines of growth. Posterior median about the same width as anterior median; lines of growth clearly seen and continue into the auricle. Auricle rather small; it begins at the level at which anterior part ends and extends into the ventral half of the shell.

Inside of shell clear. Shelf rather shallow. The blade springs from the rim near the umbone. It is short and straight, and flattened in a plane parallel to the edge of posterior median.

Pallets with well-fused cones. The composite nature of the pallet is more distinct from the inner side. The peduncles taper to a point. The boundary between the free and embedded parts of the peduncle is distinctly marked.

The specimens were collected from old piles at Sir J. Brooke Point, Palawan.

BANKIA RUBRA sp. nov. Plate 1, fig. 6.

Shell small, triangular, and thin. Width of anterior part exceeds its height. Callous anterior dorsal line strongly curved. Ridges evenly distributed and of medium size; about fifty were counted. Anterior median part as wide as posterior median. Ridges fine and most of them take origin at the ends of ridges of anterior part. This coördination, however, is not perfect. Dividing line between anterior and anterior median parts very sharp. Middle median a narrow groove; posterior median smooth. Auricle medium in size and curves slightly outward.

Inside of the shell the shelf is small and is best seen in the ventral region. The blade projects from under the rim of the umbone. It is a small structure and runs along the plane of the shell in such a way that the plane of the blade is almost at right angles to that of the shell.

Pallets of a loose cone-in-cone type. The cones are delicate, and their rims are beset with spines. These are of two types; namely, small toothlike spines along the inner rim of the cone (over ten of these can be counted), and two long stout spines

on the extreme margins of the cones. One of these is usually long, another much shorter. The outer margin is smooth.

The specimens of this animal were collected from living mangrove stems. This possibly accounts for the dark red color of all parts of the animal. The species is common near Puerto Galera, Mindoro.

Genus BACTRONOPHORUS Tapparone Canefri, 1877

Pallets large, stiltlike. From the cup of the distal end of the pallet springs a long, flat, bladelike style. This style is flat and smooth on the inner surface and lightly convex on the outer. The outer surface usually is warty.

Two species of this genus have been reported from Australia. The two described below are the first Philippine representatives.

BACTRONOPHORUS EDULIS sp. nov. Plate 2, fig. 7.

Shell comparatively large, subglobular. The anterior part is of an isosceles triangle type. Under the umbone a strongly developed callus which ends in an inward reflected knob. This knob fuses with a strongly developed shelf. Anterior part slightly wider than high. Ridges run fanlike; they are rather coarse, finely denticulate; from thirty to fifty ridges were counted in different specimens. Anterior median part narrow; less than half of middle and posterior median combined. Ridges from the anterior part continue directly into anterior median part as an obtuse triangle. Middle median a narrow strip and, as usual, darker in color; slightly elevated from surrounding region. Posterior region smooth and shows shallow lines of growth. Auricle large, runs at first at a slight angle to the posterior part, then bends sharply outward. Shelf along posterior median and auricle strongly developed. Another shelf runs along the border of the anterior and anterior median parts. Two shelves meet just under rthe knob, forming a deep angle at the place of junction. Some distance ventrally from this angle, from the middle of the posterior shelf, arises a thin, flat blade. Ventral knob large.

Pallets of typical *Bactronophorus* type; shorter and stouter than in either *Bactronophorus thoracites* (Gould) or *B. australis* (Wright). Blade resembles a certain type of scalpel with one straight and the other slanting edge.

The specimens were sent by Mr. J. Meñez, from New Washington, Capiz Province, Panay. I am told that in that place they are very abundant in dead logs along the shore. They

are collected, and eaten, either raw or cooked. They taste like oysters. At certain times they are pickled in vinegar and sold in nearby markets.

BACTRONOPHORUS FILOTEOI sp. nov. Plate 2, fig. 8.

Shell triangular and comparatively large and heavy. Umbone with a marked callus projecting inward. A small, thin, flat blade, at least 1 millimeter long, projects from the underside of callus. Anterior part is of an irregular rectangle type, with fine ridges; a little over one hundred twenty ridges counted; few of them eroded. Anterior median part about equal or slightly wider than posterior median part. The ridges of the anterior median are continuous with those of the anterior part; but on account of the anterior median being narrower than the anterior part, the ridges are closer together in the former than in the latter. Middle median part a narrow brown strip, slightly elevated. Posterior median markedly convex in its dorsal region, less so in the ventral. Auricle sharply marked from posterior median and runs at a slight angle to the latter.

Inside of the shell there are two shelves with a triangle between them. The triangular area in this species is shallower than that in *B. edulis*. The blade springs from the main or the posterior auricular shelf at the level where the auricle on one side and anterior part join their respective sides of the median part. The undersurface of the main shelf is filled with an irregular calcareous mass. The ventral knob as usual is prominent.

Pallets rather small and slender. Blade slightly shorter than the rest of pallet; both edges curved.

This species differs from *B. edulis* mainly by a finer ridging of the anterior part, by having anterior median and posterior median parts about equal in width, by shallower shelves, and by the size as well as the general shape of the pallets.

One specimen was sent from Cebu by R. S. Filoteo, in whose honor I have the pleasure of naming the species.

Genus TEREDO Linnæus, 1758

Pallets either spoon-, paddle-, or scoop-shaped. They may be cupped or not or they may even bear at their termination a calcareous knob which is usually small.

TEREDO OBTUSA sp. nov. Plate 2, fig. 9.

Shell large, heavy, and obtuse. Umbone with usual callus. Anterior part triangular; base of triangle and side about equal. Over one hundred finely denticulated ridges were counted on the anterior part. Anterior median part is slightly larger than

middle and posterior median combined. The fine ridges in this part are denticulate and appear to be closely correlated with those on the anterior part. Middle part narrow and slightly elevated. Posterior median part about half as large as anterior median; it sinks downward beginning with middle median and curves merging into auricle. Auricle obtuse, thin and transparent, of medium size and much wider than high. Inside outline of the shell deep. Shelf prominent. The blade arises at junction of the shelf and the callus knob of umbone. Blade very small. Ventral knob present.

Pallets spoon-shaped. Blade slightly excavated inside in the proximal region and convex outside. Distal regions of both sides rough. Stalks heavy and vary considerably in shape. Just before the rough area there is a periostracal band so that the pallet appears banded.

Collected from an old pile at Sir J. Brooke Point, Palawan.

TEREDO VARIEGATA sp. nov. Plate 2, fig. 10.

Shell medium in size, subglobular, and thin. Anterior part, roughly, has the shape of an equilateral triangle or that of an open fan. Height and base about equal. Ridging medium fine, with wide spaces between ridges; about forty ridges were counted. The ridges form an obtuse triangle with those of the anterior median part and at the junction they do not coordinate with each other. Anterior median about half of middle and posterior median combined. Ridges of anterior median fine and close together. Middle median narrow and slightly depressed. Posterior median slightly depressed and strongly marked from the auricle, which is still more depressed and of comparatively large size.

Shelf merely a ridge. The blade springs from the rim of the callus region and runs in the anterior median direction with the flat side almost at right angle to the shell. Knob of normal size.

Pallets spoon-shaped, short, and stout. The dark band of periostracum is present. In general the pallets resemble those of *T. obtusa*, but they are smaller and finer. This species differs from the preceding especially in the relative size of the parts of the median shell.

Few specimens were collected by R. S. Filoteo, in Cebu.

TEREDO PRINCESAE sp. nov. Plate 2, fig. 11.

Shell small, triangular, and thin. Anterior part triangular. Base of triangle longer than height. Ridges run in the form of a fan; coarse and distinct; about twenty were counted. An-

terior median very narrow; less than middle median. Ridges very close together and apparently coördinate with those of anterior median. Middle median prominent, slightly elevated. Posterior median about three times as wide as anterior and middle median together. Auricle very large and strongly bent outward.

The inside of the shell shows a very pronounced shelf at the junction of the auricle with the posterior median. The shelf is so prominent as to give an appearance that the auricle was placed by the side without fusion. At the junction of the callus and the shelf, springs the blade which runs parallel to the middle median part of the shell.

Pallets leaf-shaped, with a thin and broad expanded portion well cupped. No partition, stock short and very delicate. Pallets in their entirety very delicate and thin.

The specimens were collected at Puerto Princesa, Palawan, from a piece of wood that was exposed during low tide.

TEREDO BARTSCHI sp. nov. Plate 3, fig. 13.

Shell bluish white, small, thin, and brittle. It is of an isosceles triangle type with the dorsal line of articulation as its base. Anterior part and auricle large. Anterior part of an irregular quadrangle type; about as wide as high. Ridges of medium size and rather coarse; over forty were counted. Anterior median part slightly less than width of middle and posterior median combined. Ridges of anterior median meet those of anterior part at an angle slightly larger than 90°. They are continuations of each other. Middle median narrow; slightly depressed and indistinctly separated on both sides. Posterior median distinctly convex. Auricle of medium size; bent outward, forming an obtuse angle with posterior median part.

Inside smooth and bluish white. Shelf poorly developed. The blade springs from edge of callus and projects downward, running parallel to middle median part.

Pallets strong and stout; with a single cup. A poorly developed knob in the proximal edge of cup.

The tips of siphons are free and about equal in size. The calcareous tube instead of being single as in most of the teredos, is divided by a partition. This species and the one that follows apparently belong to the group of teredos represented by *Teredo arenaria*, *Teredo mannii*, etc., which has been under discussion by zoölogists for generations.

The specimens were collected at Sir J. Brooke Point, Palawan, from old piles.

TEREDO DUBIA sp. nov. Plate 3, fig. 14.

Shell low, wide, large, and thin; in the adult stage it becomes very narrow, unlike that of the other teredos. In young stages the shell has the general characteristics of the shell of any other animal in this group, but even the young shell does not have a typical boundary line between the anterior and the anterior median part. In older specimens this boundary line becomes entirely eliminated. In younger specimens few ridges running from the anterior directly into the anterior median part are visible. Ridges coarse and wide apart. Middle median very narrow and marked by a seamlike elevation. Posterior median part deeply eroded and smooth. Auricle recognizable as such only in very young specimens; in adults it is almost obliterated. A strong callus just under the umbone; it is large and projects in a dorsal median direction. From the middle of this callus springs a strong blade; it is straight and peglike in young specimens, but becomes curved in various directions forming an irregular corkscrew in some of the older specimens; its general course is parallel to the shell. The rim of the inner anterior and the anterior median borders is thickened in a seamlike manner. The usual ventral knob is relatively poorly developed.

Pallets strong, paddle-shaped, with short cups in which there is a low median partition.

Calcareous tube large and heavy. The whole animal and the tube may grow to almost half a meter in length and may become of considerable thickness. It grows in hard sand. The distal end of the tube is 5 centimeters under the surface. The tube sinks straight into the ground for a considerable distance; the anterior end downward, the pallets and the siphons upward. The siphons are exposed to the surface and when seen for the first time may be mistaken for actinians or almost any other cylindrical animals. The true nature of the animal is revealed after considerable digging.

A large colony of these animals was found near Puerto Galera, Mindoro. In this colony the young and the old animals live near each other. All of them are buried in sand. This apparently is contrary to W. T. Calman's suggestion [1] that the

[1] Nature 119 (1927) 104.

sand-boring forms may be the fullgrown animals of the timber-boring species which are set free by the decay of the wood. This, however, does not prove that the sand-boring teredos are not related to the wood borers. The pallets of this animal in all respects, except the size and few specific characteristics, resemble those of *T. bartschi* (fig. 13) and also the pallets of an unknown species shown in fig. 12. Both of these species were taken from wood and at distant localities; the first in Brooke Point, Palawan, the second in Dalahican, Cavite, hundreds of kilometers apart. The pallets shown in fig. 12 were found in a mangrove stump. As I realized the importance of the specimen, every effort was made to dig out the entire animal; but it went so deep into the stump, going straight into the ground, that with the instruments in our possession we had to abandon the work. It is possible for such an animal to remain in the sand when the wood disintegrates.

I consider that these three species are related to *Teredo arenaria* and *T. mannii.* The relationship of these animals, especially that of *T. arenaria* (sometimes called *Kuphus arenarius*), has been under discussion for generations. Until some one compares the shells and the pallets of these animals the discussion will not end. That the sand-boring teredos have very close relatives among the wood-boring forms is clear.

TEREDO HYDEI sp. nov. Plate 3, fig. 15.

Shell subglobular, large, and heavy. Sinus well developed. Umbone with the usual callus bending downward. Anterior part broad and high. Width to height ratio 3: 2. It resembles an irregular quadrangle. Ridges medium fine; number, as counted, not less than one hundred fifteen. Anterior median part and middle median part together almost equal to posterior median part. Ridges of anterior median finer than those in anterior part, but they coördinate with each other. Middle median part well defined on anterior side, less so on posterior. Posterior median slightly depressed. Auricle small.

Shelf short but well defined; the blade springs from shelf at a considerable distance from umbone. Middle median distinct. Knob medium in size.

Pallets of a scoop type, wide and long, deeply concave on inside and convex on outside. Junction of peduncle with blade marked by an elevation running on the concave side of blade. The pallets have a smooth surface, though they may show concentric lines of growth. They are cream white at all stages.

These animals were found in large numbers in mangrove stumps on the shore at Dalahican, Cavite. I have the pleasure of naming this species in honor of Dean Edward R. Hyde.

TEREDO APENDICULATA sp. nov. Plate 3, fig. 16.

Shell small, thin, and triangular; anterior part slightly wider than high. Ridges far apart; thirty were counted. Anterior median part about half as wide as posterior median and middle median combined. The ridges are roughly denticulate and do not coördinate entirely with those of the anterior part. Middle median part narrow. Auricle large and reflected outward.

The shelf may be well developed. The blade springs from shelf at some distance from umbone and runs parallel to shell. Knob of medium size.

Pallets of scoop type. Peduncles very short or lacking. The insertion lines are marked by two grooves on the proximal end of the pallets. The pallets are smooth and cream white in living and in preserved specimens.

This species resembles *T. hydei* but is smaller, possesses rougher sculpture, has much narrower anterior median, and has pallets without insertion stalks. The last phenomenon has never been found in any other teredo reported. I am satisfied that they were not broken.

The specimens were collected from pieces of wood exposed at low tide in Puerto Princesa, Palawan.

TEREDO PARKSI Bartsch. Plate 3, fig. 17.

Teredo parksi BARTSCH, Proc. Biol. Soc. Wash. 34 (1921) 25–32.

This species is apparently common in the Philippines. The specimens illustrated in fig. 17 were collected from floating wood in Batag Bay, Samar. The animals are very small.

Besides this collection we have in the departmental collection two more vials with the animals of this species. The locality is not given, but presumably they were collected somewhere in the Philippines.

The animals of this species have been described by Bartsch and by Miller.[2] Miller reports the species from Cavite.

THE MORE IMPORTANT LITERATURE ON SHIPWORMS

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[2] Univ. Calif. Pub. Zoöl. 26 (1924) 146.

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WRIGHT, E. P. Contributions to a natural history of the Teredidae. Trans. Linn. Soc. **25** (1866) 561–568.

ILLUSTRATIONS

[Figs. 1, 4, 8, 10, and 15 were taken by Prof. José I. del Rosario; figs. 2, 3, 5, 6, 7, 9, 11, 12, 13, 14, 16, and 17 by Mr. Juan Fontañoza. The figures vary in scale. Where the scale is not given one exact measurement is given in the explanation; any other measurements can be easily computed. Where the scale is in the figure it is always in millimeters.]

PLATE 1

FIG. 1. *Bankia triangularis* sp. nov.; outside and inside views of the shells and the pallets.

2. *Bankia oryzaformis* sp. nov.; outside and inside views of the shells and the pallets. The pallet in the center is 10 millimeters. Other sizes in the same ratio.

3. *Bankia quadrangularis* sp. nov.; outside and inside views of the shells and the pallets. Actual length of the pallet on the left is 20 millimeters. Other sizes in the same ratio.

4. *Bankia tenuis* sp. nov.; outside and inside views of the shells and the pallets.

5. *Bankia globosa* sp. nov.; outside and inside views of the shells and the pallets. The actual length of the pallet on the right is 8 millimeters. Other sizes in the same ratio.

6. *Bankia rubra* sp. nov.; several views of the shells and the pallets. The actual length of the pallet on the extreme left is 9 millimeters. Other sizes in the same ratio.

PLATE 2

FIG. 7. *Bactronophorus edulis* sp. nov.; shells and pallets. Note the narrow anterior median part. The actual length of the pallet on the left is 16 millimeters.

8. *Bactronophorus filoteoi* sp. nov.; shells and pallets. Note the wide anterior median part and the position of the blade.

9. *Teredo obtusa* sp. nov.; various views of the shells and the pallets. Note the wide anterior median part and very close ridging on the anterior part. The actual length of the pallet on the left is 14.5 millimeters. Other sizes in the same ratio.

10. *Teredo variegata* sp. nov.; shells and pallets. Note the narrow anterior median part and the coarse ridging on the anterior part.

11. *Teredo princesæ* sp. nov.; shells and pallets. The actual length of the longest pallet on the right is 3.3 millimeters. The other sizes in the same ratio.

12. *Teredo* sp.; pallets. Compare their shape with the two following species. The actual length of the longer is 16 millimeters. Other sizes in the same ratio.

PLATE 3

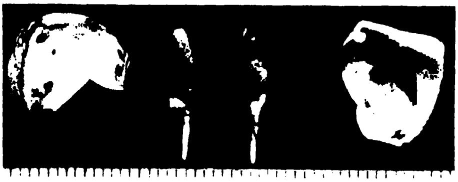
FIG. 13. *Teredo bartschi* sp. nov.; shells and pallets. The piece of tube shows double perforation for the exit of siphons. This type of tube is characteristic of this group of Teredidæ. Actual length of the first pallet on the left side is 8.25 millimeters. Other sizes in the same ratio.

14. *Teredo dubia* sp. nov.; group of shells and pallets. Paired shells and pallets shown in the center are of the smallest specimen found. Note the erosion and a peculiar ridging of the shell.

15. *Teredo hydei* sp. nov.; shells and pallets. Note the width of the anterior median and rather fine ridges on the anterior and the anterior median. Note also the stalks of the pallets.

16. *Teredo apendiculata* sp. nov.; shells and pallets. Note the narrow anterior median part and rather coarse ridging of the anterior part. Note also the absence of stalks. Actual length of the pallet on the right is 8.5 millimeters. Other sizes in the same ratio.

17. *Teredo parksi* sp. nov.; shells and pallets. Actual length of the pallet on the left is 6.6 millimeters. Other sizes in the same ratio.



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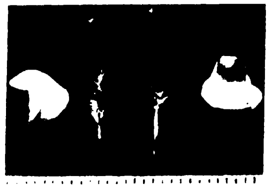

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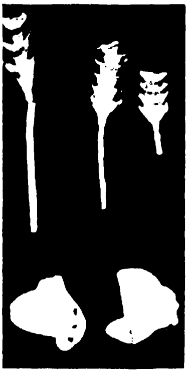

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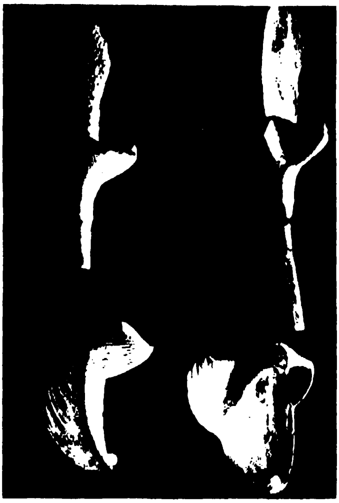
PLATE 1.



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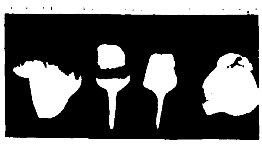

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PLATE 2.

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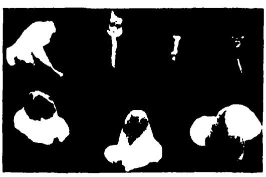

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PLATE 3.

THE MORPHOLOGY OF A HOLOTHURIAN, STICHOPUS CHLORONOTUS BRANDT

By P. B. SIVICKIS and JOSÉ S. DOMANTAY

Of the Department of Zoölogy, University of the Philippines, Manila

ELEVEN PLATES

INTRODUCTION

Stichopus chloronotus was originally described by Brandt in 1835 from specimens collected in Guahan (Guam). He placed it in the subgenus *Perideris*. Selenka (1867) in his study of similar animals collected from Zanzibar, Africa, and the Sandwich Islands, as well as Ludwig (1882), who later studied those collected from the Indian Ocean; Mauritius, Africa; and Macassar, Celebes, agreed with Brandt in their identification. Haacke (1880), however, described similar specimens collected from Mauritius under a new name, *S. cylindricus*. Later Théel (1886), Kent (1893), Fisher (1907), and Clark (1921) concurred with Brandt, Selenka, and Ludwig in their description of similar animals collected from the Friendly Islands, Australia, Hawaii, and Torres Strait.

Clark (1921) states that the geographical range of *S. chloronotus* is from Mozambique, Africa, to the Hawaiian Islands. It seems that *S. chloronotus* is confined to the Indo-Pacific region and is commonest in the East Indies and neighboring places. As far as available literature shows, Théel is the only worker on this group of animals who mentions the presence of *S. chloronotus* in the Philippines. Théel's statement is vague, since he gives neither the exact location nor a further description of the species.

Selenka (1867) appears to have been the first to work on the anatomy of *Stichopus chloronotus;* but his work is far from being complete. Semper (1868) worked on the anatomy of different forms of Philippine holothurians but did not work on *S. chloronotus*. However, he studied *S. variegatus*, which though possessing many differences in some respects is very similar to *S. chloronotus*. Théel (1886) confined himself exclusively to the spicules of *S. chloronotus*. It seems that *Sticho-*

pus chloronotus has never been adequately studied. The purpose of this paper is to describe the gross and the microscopic anatomy of this animal.

HABITAT

In the Philippines *S. chloronotus* has been collected from Puerto Galera, Mindoro, and from around the Hundred Islands, Lingayen Gulf, Pangasinan Province, Luzon.

In the vicinity of Puerto Galera, Mindoro, *S. chloronotus* is most abundant along the sandy shores of Puerto Galera Bay, especially in the Northwest Channel along the Paniquian coast of Medio or San Antonio Island. In Lingayen Gulf it appears to be less common. In both places it is a littoral form, living in water less than a fathom deep. In some places at Puerto Galera the animals are so common that they can be collected by the thousand. Occasionally individuals are found in grassy regions; never in muddy places. Usually they do not take shelter under rocks and corals and are exposed during low tide.

EXTERNAL CHARACTERISTICS

The animal is elongate, quadrangular, and somewhat tapering at both ends (Plate 1, fig. 1). Its mouth is slightly on the ventral side of the anterior end (Plate 1, figs. 1 and 2), and the anus is at the posterior. The adult ranges from 200 to 400 millimeters in length. In the middle of the body the width may reach 75 millimeters and the height 50. The largest specimens reported by Kent (1893) and by Clark (1921) do not exceed 300 millimeters.

Authorities differ in the description of the color of this animal. Lampert (1885) described it as olive green; Théel (1886), olive brown; Kent (1893), clear bottle green with the tips of the papillæ orange or scarlet; Fisher (1907), olive brown; Mitsukuri (1912), deep black with the tips of the papillæ bluish and ocher yellow; Clark (1921), deep green or almost black with the tips of the papillæ brown orange. The Puerto Galera and Lingayen Gulf specimens are deep green with lighter irregular bands under sunlight with the tips of the papillæ slightly lighter or orange in color. One specimen, however, was found with the body distinctly lighter in color than usual and with the papillæ banded with deep orange. The orange tips of the papillæ can be extended and retracted.

The interradial spaces are naked and plain. The dorsolateral and ventrolateral radii are provided with papillæ alternately arranged (Plate 1, fig. 1). This arrangement is distinct

in the former. The ventral surface shows that it is formed by three of the five radii and is provided with three rows of pedicels or tube feet. The middle row of tube feet is twice as wide as the lateral ones (Plate 1, fig. 2). The difference in width of these three rows of tube feet is due to the fact that the middle row takes up an entire radius while each of the lateral ones occupies only half of the radius, the other half is taken by the ventrolateral papillæ. The distinct alternate arrangement of the dorsolateral papillæ is due to the absence of the tube feet in this region, so that the entire radius is left to the papillæ.

Stichopus chloronotus has twenty tentacles. A few specimens are recorded with eighteen or nineteen tentacles only. The stalks of the tentacles are cylindrical, resembling an Indian club. They are usually stouter at the base and are 15 to 25 millimeters in length and 4 to 7 millimeters in diameter at the widest part. The distal end is disk-shaped or more or less like a powder puff (Plate 1, fig. 2). Close examination of the disk shows four main branches, each one divided and subdivided into many smaller branches, thus giving the appearance of a powder puff. The bases of the tentacular stalks are arranged in a circle and are united with each other at the margin of the peristome (Plate 1, fig. 2). The tentacle is provided with several types of spicules which are described under the skeletal system.

THE SKELETAL SYSTEM

The skeletal system in different parts of the body consists of variously shaped spicules, ranging from 37 to 796 microns. Scattered within the body wall are the simple tables with four short pillars (Plate 2, figs. 22–29) and C-shaped spicules (Plate 2, figs. 30, 31) about 37 microns in their longest axis. The simple tables are embedded in the pigment layer of the body wall and are superficial in position (Plate 9). The C-shaped spicules are scattered in the connective-tissue layer (Plate 9).

In the papillæ are found the same types of spicules as in the body wall with the addition of another type in the form of rods (Plate 3, fig. 19). These rods, which are either curved or branched, and average 370 microns in length, strengthen the distal portion of the papillæ.

The tentacles are provided with many forms of spicules. The stems of the disk-shaped part of the tentacles have small quadrangular rods (Plate 2, figs. 3, 4). The distal part of the main stalk of the tentacles contains large quadrangular rods

slightly racemose at both ends. These rods are either curved or straight and range from 647 to 796 microns in length (Plate 2, figs. 1, 2). The general arrangement of these rods is at right angles to the longitudinal axis of the stalk. The majority of these rods are curved and follow the curvature of the cylindrical stem. Proximally there are very numerous small rosettes; some are simple and incomplete, while others are complex and appear like small sieve plates (Plate 2, figs. 10–16). These are scattered all over the wall of the main stem of the tentacle. In the proximal half of the stalk the supporting rods are entirely wanting and the rosette forms are fewer. In this part the spicules in the form of large tables predominate (Plate 2, figs. 5–9). The majority of these tables have six pillars, although some smaller ones have only four (Plate 2, fig. 5). They range from 56 to 148 microns in height. Their bases are perforated like those of regular sieve plates (Plate 2, fig. 6). Their pillars are connected with each other by crossbars and are spinous or racemose at their tips. At the proximal end, next to the rim of the mouth, are numerous C-shaped spicules, which are the typical body-wall spicules.

At the very tip of the tube feet are large supporting sieve plates that lie close together, and the group appears like a single large sieve plate. Those in the central portion have no definite shape; some are circular, others are irregular (Plate 3, fig. 2), while those at the margin or rim of the tip are uniform in size and shape (Plate 3, fig. 1). They are usually characterized by two large holes at the center surrounded by several smaller ones. At the sides, near the tip, there are many spinous supporting rods. Some of these rods are similar to those of the papillæ, but the majority are branched at the middle part, usually on one side (Plate 3, figs. 16–19). These side branches at the middle vary from simple spinous processes to complex sieve-plated ramifications. The latter are usually accompanied by slight ramifications on the oppsite side (Plate 3, figs. 16, 17). They are more or less uniform in size. The average length of these rods is 333 microns. They are arranged parallel to each other at right angles to the longitudinal axis of the pedicel. They are usually found beneath the epidermis in the connective-tissue layer. Near the surface there are many small simple tables which are scattered all over the proximal part of the pedicel. Some of these tables have short pillars (Plate 2, fig. 25). Aside from all these spicules in the tube feet there are C-shaped ones.

Even the internal organs are provided with spicules and calcareous deposits. The calcareous ring, the stone canal, and the madreporite are filled with calcareous material usually in the form of a reticular network. In the walls of the water-ring vessel, in the Polian vesicles, and in the ampullæ of the tentacles there are numerous rodlike spicules arranged parallel to each other (Plate 3, figs. 6–8). The suspensors of the pharynx are provided with similar spicules. The gonads have ><-shaped spicules and few rodlike ones (Plate 3, figs. 3–5). The trunks of the respiratory trees possess complex rosettelike spicules, which appear like small sieve plates and range from 110 to 190 microns in diameter (Plate 4, figs. 5, 6). Those at the distal part are mixtures of simple and complex forms with various sizes from the minimum to the maximum, while those at the proximal are uniformly of the maximum size. The wall of the alimentary canal is also provided with numerous rodlike, ><-shaped, and some X-shaped spicules scattered from the pharynx to the cloacal region (Plate 3, figs. 10, 11). When intestinal appendages are present they also have some rod-shaped spicules in their walls, especially those that are just beginning to protrude from the wall of the canal.

The calcareous ring is made of well-developed calcareous plates fused to each other and surrounding the pharynx (Plate 3, figs. 20, 21; Plate 5, fig. 1; Plate 6). There are twenty plates fused together to form a ring. Five of these plates, called radial pieces, lie at the anterior ends of the five pairs of radial longitudinal muscles at the place of their attachment (Plate 3, fig. 20; Plate 7, fig. 3). The other fifteen are called interradial pieces (Plate 3, fig. 21). The two dorsal radial pieces are provided with conspicuous, bifurcate, posterior prolongations and are better developed than those of the ventral. The interradial pieces are all symmetrical and smaller than the radial. They are slightly concave behind and have a single median point in front (Plate 3, fig. 21). On each side of this median point the plate is hollowed for the reception of a tentacular ampulla and for the attachment of the basal part of the tentacular canal. According to Clark (1907) these plates arise from calcereous bars, which branch more or less irregularly; the branches anastomose and fuse until solid plates are formed. The plates are somewhat triangular in form. It seems as if there is an agreement between the number of the tentacles and the total number of plates in the calcareous ring. This is shown by the fact that the tentacular ampullæ are of the same number as the radial

and the interradial plates. The anterior part of each of the radial plates bifurcates, producing an indented part for the passage of the radial nerve cord from the circumoral nerve ring (Plate 3, fig. 20; Plate 5, fig. 1). Microscopically these plates are not homogeneous but are made up of a reticular network of calcareous filaments, or bodies, similar to that of the stone canal (Plate 8, figs. 1–6). This reticular network of calcareous bodies is intermixed and inclosed by fibrous connective tissue.

THE BODY WALL

The body wall of *Stichopus chloronotus* is fairly thick but not firm, and the thickness is almost uniform throughout (Plate 6). As in other holothurians it consists of five parts (Plate 9); namely, a cutis and a layer of epithelial cells which make up the epidermis; a layer of connective tissue in which are located the calcareous deposits, pigments, and some spheruliferous corpuscles; a layer of circular muscles; two radial bands of longitudinal muscles for each ambulacrum; and an inner epithelium which lines the body cavity.

Epidermis.—The outermost part of the epidermis, or cutis, is a thin homogeneous layer secreted by the epithelial cells. The epidermal epithelium is composed for the most part of two kinds of cells, the supporting cells and the sensory cells. The supporting cells are the most abundant and they make the greatest bulk of the epidermis. They are usually columnar cells tapering toward the connective-tissue layer (Plate 8, figs. 11, 12). In addition to these there are a few clear glandular cells in the region of the tentacles. It is believed that this third kind of cell is similar to the gland cells identified by Clark (1907) in the epithelial cells of Molpadidæ. The epidermal layer in the distal part of the branches of the tentacles is much thicker than that of the side. It is about 40 microns in thickness as compared with that of the side which is only about 18 microns thick (Plate 7, fig. 2). This is due to the greater number of the supporting and sensory cells. Most of the sensory cells are spindle in form (Plate 8, figs. 11, 12). Each of the minute branches of the tentacle is really an association of these sensory cells with some supporting cells similar to the touch papillæ in Molpadidæ as found by Clark (1907).

Connective-tissue layer.—The connective-tissue layer forms the greater part of the body wall (Plate 9). Unlike that of

other holothurians, the thickness of this layer is practically uniform throughout. This is the layer in which most of the calcareous deposits are lodged. A small piece of this layer when examined fresh under the microscope reveals many connective-tissue fibers with some spheruliferous and oval corpuscles (Plate 8, figs. 9, 10, 15). The oval corpuscles vary in size from 30 to 37 microns, while the spheruliferous are more or less uniform, about 23 microns in diameter. The connective-tissue fibers, like those of other holothurians, are prolongations of cells embedded in a homogeneous matrix. They are very long, and the ends are split into many fibrils. It is possible that many of the fibers may have no cellular connections because of the abundance and the length of fibers compared with the small number of cells. Histologically the superficial fibers are loose and spongy, filled with spheruliferous and oval corpuscles, some pigment cells, and few spheruliferous wandering cells. The inner or deeper layer is closely filled with the fibers running almost parallel to each other. The nuclei of a few cells are seen among those fibers together with some corpuscles scattered in a limited number. In the tentacle in this particular layer are the supporting rods. The perpendicularly arranged muscular tubules are also found in this layer. These, however, are limited to the dorsal region.

Muscular layer.—The circular-muscle layer runs almost completely around the body cavity, except in the ambulacral regions just external to the lining epithelium (Plates 6 and 9). It is uniform in thickness throughout, except at the approach of the cloacal opening where it becomes better developed and forms a sphincter. This sphincter partially closes and opens the anus during respiration, allowing the water to enter and leave the respiratory trees.

The radial longitudinal muscles are arranged in pairs, one on each side of the radial water vessels. Anteriorly the paired bands of muscles are very close to each other, where they form a single tube attached to the radial plate of the calcareous ring (Plate 7, fig. 3). Posteriorly the muscles of each radial pair become reduced. They taper gradually until they terminate at the sphincter, aiding the latter in the opening and the closing of the anus during the respiration. The median edges of the paired, radial, longitudinal muscles are attached to the lateral wall of the radial water canal, while the outer edges are free

(Plate 7, fig. 1; Plate 9). The entire ventral side of this muscle layer is attached by connective-tissue strands to the circular-muscle layer (Plate 10, fig. 4).

Lining epithelium.—The inner epithelium, commonly called the cœlomic epithelium, is the innermost layer of the body wall. It is composed of flat polygonal cells. It lines the circular and radial longitudinal muscles as well as the radial water canal and the ampullæ of the tube feet (Plate 7, fig. 1; Plate 9). Its thickness is more or less uniform, about 18 microns, except at the ampullæ of the tube feet where it is composed of a single layer of flattened cells about 5 microns thick.

THE BODY CAVITY

The body cavity of *S. chloronotus*, like that of other holothurians, is spacious, extending from the oral disk to theposterior tip of the body without any marked separation into parts. Longitudinally the cavity is incompletely traversed by three mesenteries, which suspend the three coils of the alimentary canal. These are the dorsomedian mesentery, suspending the stomach and the anterior portion of the small intestine; the lateral mesentery, supporting the rest of the small intestine; and the ventral mesentery, supporting the large intestine, or the posterior part of the alimentary canal. Posteriorly it is traversed by strands of connective tissue with muscle fibers supporting the cloaca (Plate 6). The body cavity is lined with a thin, flattened epithelium, which was described in connection with the body walls. The fluid content of the body cavity is largely water containing albuminous material with numerous amœbocytes (Cuénot, 1891), or wandering cells, (Durham, 1892) and some corpuscles (Plate 8, figs. 15, 16). Some of the corpuscles are similar to those found in the connective-tissue layer of the body wall. Since the body cavity is in constant communication with the water-vascular system through the madrepore body and the stone canal, it is thought that the fluid of the body cavity may be identical with that of the water-vascular system.

THE WATER-VASCULAR SYSTEM

The water-vascular system is composed of the circular canal, the five radial canals, the tentacular and ambulacral canals with their ampullæ, the stone canal, and the madrepore body.

The water-circular canal lies posterior to the calcareous ring around the pharynx and gives off five main radial vessels, which run to its inner surface (Plate 5, fig. 1; Plate 6). Unlike other holothurians, in this species the lumen of the circular

canal and the main radial vessels are large (about 5 millimeters in diameter), and their walls are thin. Both the circular and the main radial canals are attached to the outer wall of the pharynx and are supported by many connective-tissue strands with muscle fibers (Plate 6). The wall of the circular canal consists of four layers, as follows: An outer epithelial layer of cells which is continuous with the lining epithelium of the body cavity; a layer of connective tissue consisting chiefly of fibers containing a few wandering cells and rodlike spicules; a circular-muscle layer; and an internal epithelium of cilated cells (Plate 10, fig. 3). Close to the posterior part of the circular canal and partly related to it is the pharyngeal blood ring (Plate 5, figs. 1, 2; Plate 6).

The five main radial vessels run anteriorly to the calcareous ring. They are largest at the place where they leave the circular canal, but rapidly decrease in size by giving off four branches from which the tentacular canals are formed. The two pairs of branches are given off at different levels, and each branch supplies a tentacle as can be seen in Plate 5, fig. 1. Each of the radial canals runs forward under the median indented part of the radial piece of the calcareous ring (Plate 5, fig. 1; Plate 7, fig. 3), then it bends outward and backward to the body wall along the inner side of the hyponeural canal extending posteriorly to the tip of the body where it terminates in a rudimentary ambulacral appendage. Histologically the wall of the radial canal differs from the circular canal chiefly in the absence of a circular-muscle layer. The tentacular canals, which are really the side branches of the radial canals, differ histologically from the ring canal in the presence of valves and a thin layer of longitudinal muscles. The same thing is true of the ampullæ of the tentacles, but their body layers are much thinner than those of the tentacular canal and they have no valves. In some of the tentacular ampullæ many dead wandering cells accumulate, which usually make the tips brownish black. These tentacular ampullæ are backward extensions of the tentacular canals outside of the calcareous ring to which they are closely attached (Plate 5, fig. 1; Plate 6). They are prolonged considerably over the posterior margin of the circular canal and hang freely in the body cavity. Each of the five radial vessels gives off side branches known as ambulacral canals. The openings of these canals from the radial vessel are provided with tiny valves. In the median, ventral, radial vessel the ambulacral canals lead to the tube feet and are known

as pedal canals (Plate 9). The medial ambulacral canals of the two ventrolateral radial vessels lead to the pedal canals, but the lateral ones lead to the papillæ and are known as appendicular canals. The ambulacral canals of the two dorsolateral vessels lead to the appendicular canals. Each pedal and appendicular canal is provided with a little ampulla which extends into the body cavity (Plate 9). Histologically the pedal and the appendicular canals are similar. Each has a connective-tissue layer, a longitudinal-muscle layer, and a lining epithelium.

Aside from the five radial vessels, which arise from the circular canal, there are four interradial tubes in the form of a dorsal stone canal and three Polian vesicles (Plate 5, fig. 1; Plate 6). The stone canal is an unbranched tube arising from the circular canal close to the pharyngeal blood ring in the median dorsal interradius. It lies between the two layers of the dorsal mesentery. It appears as an irregular twisted tube, which runs forward and upward and terminates within the body cavity in a whitish heart-shaped madrepore body (Plate 5, fig. 1; Plate 6). This madreporite is slightly concave on one side and convex on the other with a slightly pointed apex. The entire outer region is porous and covered with ciliated epithelial cells. Internally it is divided into chambers (Plate 11). The central cavity is directly continuous with the lumen of the stone canal and opens into the body cavity through the numerous pores. The madreporite is composed chiefly of closely interlocked, irregularly branching, calcareous bodies. The stone canal consists of connective tissue intermixed with calcareous bodies and covered externally with flat epithelium of the body cavity. Internally it is lined with conspicuous, columnar, ciliated cells (Plate 10, fig. 5; Plate 11). These cells are low and cuboidal on one side, but on the opposite side they become much higher or columnar and bear prominent cilia as long as, or longer than, the height of the cells themselves (Plate 10, fig. 5).

The Polian vesicles are usually three in number, although a few abnormal cases with a large number are recorded. Usually two of the three vesicles leave the circular canal at the left ventral interradius and one at the right ventral interradius (Plate 5, fig. 1; Plate 6). In some cases this condition may be reversed, two at the right and one at the left. One abnormality recorded is a large branched Polian vesicle at the left ventral interradius together with four rudimentary ones, three of which are at the right ventral interradius. The mi-

croscopic structure is similar to that of the circular canal, but the circular-muscle layer is thicker.

The fluid contained in the water-vascular system, as previously noted, appears to be the same as that of the body cavity because of the close relation existing between the two through the madreporite. In the water-vascular fluid, however, there is a large number of corpuscles and wandering cells (amœbocytes).

THE ALIMENTARY CANAL

The mouth is a circular opening at the center of the oral disk, situated at the anteroventral end of the body (Plate 1, fig. 2). It has neither armature, teeth, nor papillæ and is placed in the midst of the tentacular circlet. It is connected with the stomach by a straight, short, funnel-shaped tube which is considered as the pharynx by Clark (1907) and others. Some workers, for example Sedgwick (1909), consider it the œsophabus. The anterior portion of the pharynx is somewhat larger than the posterior part and resembles an attenuated funnel. The pharynx may be completely closed anteriorly through the contraction of the well-developed sphincter muscles. Arising from its outer wall are numerous tiny connective-tissue strands with muscle fibers. These strands are impregnated with many rod-shaped spicules, which range from 37 to 92 microns in length (Plate 3, figs. 6–8). Some of these strands of connective-tissue fibers, called suspensors (Gerould, 1896), attach the pharynx to the inner surface of the calcareous ring as well as to the circular and main radial canals. Posterior to the pharynx is the stomach, which is not distinctly marked off from the intestine (Plate 6). Next to the stomach is the intestine. The first half of the intestine corresponds to the vertebrate small intestine and extends posteriorly and then turns forward and extends to almost near the anterior end of the body cavity (Plate 6). Here it bends backward ventrally to form the large intestine. It extends posteriorly to the cloaca, which opens through the anus at the hind end (Plate 6). The hinder part of the large intestine is rather abruptly enlarged where it forms the cloaca and receives the respiratory trees (Plate 6). The alimentary canal is attached to the body wall along its whole length by mesenteries, which according to some authors are derived mainly from the dorsal mesentery of the larva. This mesentery consists of a very thin sheet of connective tissue containing isolated muscle

fibers running in various directions and many spheruliferous corpuscles. The pharynx, the stomach, and the first part of the small intestine are attached to the body wall by the dorso-median mesentery to the dorsal interradius. At its first bend the mesentery passes across the left dorsolateral radius to the left lateral interradius where it supports the part of the small intestine running forward. At the second bend the mesentery passes across the intervening radii and interradii into the right ventral interradius where it supports the large intestine. The arrangement of mesenteries in general is similar to that described by Selenka (1867). Both the lateral and the ventral mesenteries are perforated by many holes, which allow a continuous flow of the body fluid.

Histologically the wall of the alimentary canal is practically the same throughout. It consists of five layers, as follows: An outer layer, or epithelium, which is continuous with the lining epithelium of the body cavity, corresponding to the visceral peritoneum of vertebrates; a thin outer layer of connective tissue; a muscular layer composed of circular- and longitudinal-muscle fibers; a thick inner layer of connective tissue; and a lining epithelium corresponding to the mucosa of vertebrates (Plate 10, figs. 2, 6).

The relative thickness of these layers, however, differs in various parts of the alimentary canal. The muscle layer of the pharynx at the posterior part contains longitudinal fibers within the circular series. The inner, thicker, connective-tissue layer is impregnated with many rod-shaped spicules, which range from 56 to 94 microns in length. The epithelial lining of the pharynx is thrown into longitudinal folds and is covered by a delicate cuticle.

In the wall of the stomach both the circular- and the longitudinal-muscle layers are well developed. The inner connective-tissue layer is vacuolated and is provided with X-shaped spicules 50 to 74 microns in height (Plate 3, figs. 10–15). The lining epithelium consists of columnar epithelial and gland cells. This layer is thrown into prominent longitudinal folds at the lateral and dorsal side of the stomach. These folds are absent on the ventral side.

In the small as well as in the large intestine the longitudinal-muscle fibers are poorly developed. A few bundles of these fibers are entangled within the outer reticular part of the inner connective-tissue layer (Plate 10, fig. 2). The circular-muscle layer, however, is well developed. The inner connective-tissue

layer of the small and the large intestine is thick and is divisible into two regions; namely, an outer, vacuolated, reticular layer with coarse fibers and in inner, homogeneous, fibrous layer with finer fibers (Plate 10, fig. 2). This connective-tissue layer of the intestine is provided with X-shaped and rod-shaped spicules. The lining epithelium is composed of columnar cells (Plate 10, figs. 2, 6). It differs from that of the anterior portion of the canal in having no gland cells. It is also thrown into longitudinal folds, which are not as prominent as those in the stomach. The folds are more or less uniform in thickness all around, so that when the intestine is full of food material, the wall is usually distended and the contents are visible from all sides of the canal.

Histologically the cloaca is similar to the other regions of the canal (Plate 10, fig. 6). The muscular layer is like that of the stomach. The inner connective-tissue layer is very thick and is composed of the same parts as that of the intestine. It possesses a mixture of rod-shaped and ><-shaped spicules. The epithelial lining is similar to that of the intestine. Numerous strands of connective tissue with muscle fibers that are outgrowths of the wall of the cloaca attach the cloaca to the body wall (Plate 10, fig. 6). These strands differ from the suspensors of the pharynx by the absence of spicules. Wandering cells of various forms are abundant in the internal epithelial layer throughout the alimentary canal.

Stichopus chloronotus, unlike most of the species of holothurians, has no Cuvierian organ.

THE RESPIRATORY TREES

The respiratory trees, sometimes called branchial or gill trees, consist of two main branches, the left and the right. They arise from a short common trunk on the anterodorsal part of the cloaca (Plate 6). Each main branch consists of a single main tube, which bears numerous conspicuous lateral outgrowths and extends forward close to the calcareous ring. In a few cases the left branch is longer than the right, although normally the two are practically of equal length. The greatest portion of the left branch is in close relation with the blood plexus of the dorsal intestinal vessel (see below). The right one is usually free in the body cavity, thus differing from other holothurians where it is closely attached to the body wall. The bulbular ends of the lateral outgrowth when examined fresh under the microscope can be seen to contract and relax.

This contraction and relaxation is associated with the incoming and outgoing of water through the anus during the process of respiration and is possibly caused by the alternate contractions of the circular- and longitudinal-muscle layers of the system. The water that is taken in through the anus is forced into the finest branches, which end in small enlargements, or bulbs. From these the water diffuses through the walls into the body cavity.

The respiratory tree is an outgrowth of the intestine and histologically is similar to it (Plate 10, fig. 1). The outermost layer is a thin epithelium, composed of flat and irregular polygonal cells outside a thin layer of connective tissue. Below the latter is the muscular layer, composed of circular and longitudinal muscle. Following the muscular layer is a thick connective tissue, which is vacuolated and impregnated with complex rosette-shaped spicules ranging from 110 to 190 microns in width (Plate 4, figs. 5, 6). These spicules are found only in the main trunks of the left and the right respiratory trees and are practically absent in the lateral branches. The last layer is the lining epithelium, composed of cuboidal epithelial cells. In the lumen, in some sections, are numerous wandering cells. There are no openings by which the cavity of the bulbular ends or ampullæ of the respiratory trees could communicate directly with the body cavity.

THE HÆMAL SYSTEM

The principal parts of the hæmal, or blood, system of *S. chloronotus* are the pharyngeal blood ring, the dorsal and ventral intestinal vessels, the radial perihæmal canals, and the lacunar spaces. The pharyngeal blood ring, which forms the center of the system, lies immediately behind the water-ring canal (Plate 5, fig. 1; Plate 6). Histologically it does not have the appearance of a blood ring as its lumen is divided into many chambers (Plate 5, fig. 2). Its wall is made up of connective tissue with few rodlike spicules and spheruliferous wandering cells (Plate 4). Within the chamber, however, there are groups of many blood corpuscles and few wandering cells. The blood corpuscles are practically uniform in size and shape (Plate 8, figs. 17, 18). They are circular and measure about 2 to 3 microns. Some of the chambers communicate with the water-ring canal and others with the peripharyngeal sinus. This affords a chance for the wandering cells to get into the chambers of the pharyngeal blood ring together with the blood corpuscles.

The dorsal intestinal vessel lies at the line of union of the dorsal mesentery and the alimentary canal, while the ventral vessel lies on the opposite side. The two vessels are quite distinct from the canal and are connected to the lacunar spaces of the latter only by numerous short cross vessels forming a plexus called "rete mirabile" by Sedgwick (1909). The rete mirabile of the dorsal intestinal vessels in the region of the stomach and the first part of the small intestine is a typical plexus along the vessel giving off uniform parallel short cross vessels to the lacunar spaces of the alimentary canal (Plate 6). In the region of the last part of the small intestine the dorsal vessel gives off numerous long fine branches forming a great plexus which almost entirely inwraps the left respiratory tree (Plate 6). There is a close relationship between the plexus and the branches of the respiratory tree, the latter being inclosed or surrounded by the former (Plate 4, fig. 3). Beyond this the main vessel runs posteriorly and gives off several shorter and stouter cross vessels to the intestine. Then it lies very close to the canal in the region of the large intestine and disappears into lacunar spaces.

The ventral hæmal vessel passes from the pharyngeal blood ring to the posterior part of the alimentary canal without forming a plexus with the respiratory tree. In the first two-thirds of the vessel, in the region of the small intestine, a large cross vessel connects the anterior and the middle part of the vessel (Plate 6). Posteriorly, in the region of the large intestine, the main vessel becomes smaller, lies close to the canal, and terminates in lacunar spaces.

As in other holothurians belonging to the same order there are five radial perihæmal canals. In the diagram of the cross section of the body wall through the radial nerve cord and its accompanying vessels (Plate 9, fig. 35) the axial space between the outer wall of the radial water canal and the deep oral system of the radial nerve cord is the perihæmal sinus.

The gonads are directly supplied with blood from the pharyngeal blood ring (Plate 6).

Externally the blood vessels appear like true vessels, but histological examination shows that they are filled with cells and strands of connective tissue with the blood corpuscles between these strands (Plate 4, fig. 2). Even those that have a lumen do not appear like true blood vessels. The wall is a structure not as sharply defined as that of the blood vessels of vertebrates. It is made up of loose strands of connective tis-

sue mixed with a few cells and surrounded by an outer, indistinct, muscular layer. The fluid within the system is a colorless plasma with occasional wandering cells.

THE REPRODUCTIVE SYSTEM

The reproductive system of *S. chloronotus* consists of a genital duct and tufts of genital tubules. The duct opens to the exterior in the mid-dorsal interradius about 10 millimeters behind the tentacles (Plate 1, fig. 1). The duct that runs ventroposteriorly from this genital opening into the dorsal mesentery up to the pharyngeal blood ring is not very distinct. It is usually much dilated and hidden in the mesentery. Beyond the pharyngeal blood ring, however, the duct can be seen distinctly within the dorsal mesentery. About 5 millimeters posterior to the blood ring it divides into two bundles of genital tubules (Plate 6). These bundles of genital tubules are located on both sides of the dorsal mesentery, and each of them consists of four to seven, or even more, genital tubules hanging freely in the body cavity. They branch dichotomously into smaller branches and extend sometimes as far as the posterior part of the body cavity. Some of them may interlock with the smaller branches of the respiratory trees.

The wall of the gonads (testis or ovary) is made up of the usual peritoneal epithelium, a thin layer of circular muscle fibers, a layer of connective tissue with some lacunar spaces, and an inner germinal epithelium which is scattered in more or less irregular masses (Plate 4, figs. 1, 4). The germinal epithelium produces either sperms or eggs, as the case may be, the sexes being separate. Externally there is not much difference between the testis and the ovary. The eggs are typical echinoderm eggs. The mature unfertilized egg is from 55 to 112 microns long; it has a large clear nucleus and one prominent nucleolus (Plate 4, fig. 1). The immature eggs within the ovary are suspended by a delicate membrane from the germinal epithelium and are really within the egg follicles. The sperm cell is minute, approximately 1 micron in length. The mature sperm when seen under an oil-immersion lens appears as a pear-shaped body with a short tail, free within the lumen of the tubule. Younger male germ cells in early stages of spermatogenesis are usually found grouped together within the germinal epithelium (Plate 4, fig. 4).

THE NERVOUS SYSTEM

The nervous sytem of *S. chloronotus* is divided into two parts, the ectoneural ventral system and the deep oral system. The first consists of the circumoral nerve ring with the tentacular and buccopharyngeal nerves and the five radial, longitudinal, nerve cords with branches to the tube feet, the papillæ, and the integument. The latter is composed of a double radial nerve band closely applied to the radial nerve cord of the ectoneural ventral system (Plate 7, fig. 1; Plate 9).

The circumoral ring is flattened and is fairly prominent. It is about 1 millimeter wide and 0.2 millimeter thick. It lies beneath a connective-tissue layer immediately internal to the bases of the tentacles anterior to the calcareous ring (Plate 5, fig. 1). It gives rise to the tentacular nerves, which run forward on the inner face of the stalk of each tentacle, forming a wide sheet. It is thickest near its base and smallest at its distal part. This gives off fibers directly to the sensory part of the tentacles. Some isolated fibers find their way to individual neuroepithelial cells. The buccopharyngeal nerves extend radially inward from the nerve ring to the buccal sphincter muscles, then turn backward along the pharynx. They innervate the muscles and the epithelium of the pharynx.

The radial nerves form a thick outer cord as a part of the ectoneural ventral system and two thin closely attached inner bands as a part of the deep oral system. The thick outer portion is considered to be the sensory center and the thin inner portion a motor center (Herouard, 1887). The inner bands anteriorly divide and subdivide into branches and innervate the neighboring longitudinal and circular muscles and also send nerves to the tube feet. The outer cord runs posteriorly as far as the cloacal opening and gives off branches to the tube feet, as pedal nerves, and also to the papillæ and the integument. The side branches of the radial nerve cord are of two groups. Those of one group run to the interradius where they constitute a true plexus, homologous with the superficial plexus of the test of the sea urchin (Herouard, 1887); those of the other group run along the ambulacral tube and innervate the walls of the tube feet and the papillæ (Plate 9, fig. 35). Each radial nerve is accompanied by a tubelike cavity, closed at both ends, called the hyponeural canal on its inner side and the epineural canal on its outer side (Plate 7, fig. 1; Plate 9). The latter extends

to the upper and the inner side of the circumoral nerve ring and on the inner side of the tentacular nerve.

THE SENSE ORGANS

The tentacles constitute the principal organs of touch, although the tube feet may also function as such (Plate 1, figs. 1, 2). Sensory nerve cells that are the immediate seat of tactile sensations are scattered all over the epithelial covering of the body. They are most abundant in the extremities of the tentacular branches (Plate 7, fig. 2).

PARASITES

Stichopus chloronotus at Puerto Galera often harbors a commensal fish, *Fierasfer homei* Richardson (Plate 1, fig. 3).[1] A similar fish inhabits the body cavity of *Holothuria mammifera* (Kent, 1893). The colored drawing given by Kent (his fig. 10, Chromo XII) is similar in external appearance to the commensal fish that seeks shelter in *S. chloronotus*, but of a different species. Fishes of the same genus have also been reported by Kent (1893) to live in the mantel cavity of *Meleagrina margaritifera*.

Stichopus chloronotus shelters other commensal animals. Among these is an annelid, a species of *Gastrolepidia*, whose color closely approximates that of its host and whose form enables it to retain its position even against a considerable effort to detach it (Clark, 1921). Another one, reported by Kent (1893), is a species of flat large-scaled worm, closely allied to *Polynoë setosa*, which clings closely to the integument in the interspaces between the projecting papillæ; one of the Puerto Galera specimens were found with similar animals. In life it can be scarcely detected owing to is perfectly harmonizing colors. The Puerto Galera and Lingayen Gulf specimens are not entirely free from such or similar parasites.

The intestines of almost all the specimens of *S. chloronotus* collected in 1926 show intestinal appendages in the form of long tubules (Plate 8, fig. 7). The tubules are double walled, and within the inner tube are many microscopic, embryolike organisms that apparently are parasites (Plate 8, fig. 8). An examination under an oil-immersion lens shows that these organisms are made up of amœboid cells with clear cytoplasm and reticular nuclei. The greatest portion of this organism is made up of granules which do not show any indication of being

[1] Identified by Mr. H. R. Montalban, of the Bureau of Science, Manila.

cells (Plate 8, fig. 8). The nature of these intestinal appendages needs further investigation.

J. Müller (1852) mentioned the development of testaceous gasteropods within a peculiar tube attached to the intestinal vessels of *Synapta digitata*. Baur (1861), on the same problem, demonstrated that the molluscigerous sac is an organism complete in itself that is called *Helicosyrinx parasitica*. The ones found in *S. chloronotus* are different from those described by Müller and Baur, and they are reported here simply because they constitute a puzzling problem for the morphology worker, especially in the beginning stages of the work.

DISCUSSION

Although *Stichopus chloronotus* has been studied by several workers their descriptions are brief and incomplete. They all agree on the general body form, the arrangement of the papillæ and the tube feet, the number of tentacles, the Polian vesicles, the stone canal, and the presence of certain body spicules. They differ, however, in the description of the body color. The differences in the colors of the animals described may be due to differences in the localities from which they were obtained and to the difference in the condition of the animals when described. Those obtained from different localities vary from each other, showing that different environmental condition affect the color of the animal. *Stichopus chloronotus* described by most of the workers were preserved specimens whose color must have changed as a result of preservation. Théel (1886) said that his specimens were contracted and wrinkled showing that they had been preserved for sometime. Fisher (1907) also must have described preserved specimens as the color he gave is the same as that of Théel, which is olive-brown, the actual color usually associated with the specimens when preserved in 10 per cent formalin.

The list of types of spicules as found and described by most of the authors is not complete. Although Théel and Fisher mentioned many types of spicules, they left many unmentioned and undescribed. The large quadrangular supporting rods (Plate 2, figs. 1–3) and large tables (Plate 2, figs. 5–9) found in the wall of the stalk of the tentacles were never mentioned. It is likely that these types of spicules were overlooked by them, or possibly they are peculiar to the Puerto Galera form. Previous workers made no mention of the spicules of the internal

organs, like the rod-shaped deposites in the walls of the alimentary canal, the water-circular canal, the Polian vesicles, the suspensors of the pharynx, etc.; the X-shaped and ><-shaped spicules in the walls of the alimentary canal, and the rosette-shaped spicules in the main respiratory tree trunks. All types of spicules previously reported are found in Puerto Galera specimens. Some of the spicules of *S. chloronotus* are similar to those of *S. tropicalis* Fisher, *S. variegatus* Semper, and others of the same genus. The C-shaped spicules (Plate 2, figs. 30, 31), the simple tables (Plate 2, figs. 22–29), and the spinous supporting rods of the pedicel (Plate 3, figs. 16–19) appear to be present in most of them.

It is probable that some of the spicules reported here for the first time are absent in the specimens described by Théel (1886), Fisher (1907), and several others. Fisher reported that the rosettes, which Théel found in his specimens, were not present in the Hawaiian form. The spicules in the tentacles of *S. chloronotus* may be easily overlooked in preserved specimens in which the tentacles are usually retracted inside the buccal cavity. In such specimens the tentacles cannot be very well exposed for spicule examination. The spicules in the form of large tables (Plate 2, figs. 5–9), which are located in the proximal part of the stalks of the tentacles, would certainly be overlooked in the contracted form. The large quadrangular supporting rods, however, cannot be missed if the tentacles are examined microscopically, because they lie just posterior to the expanded part of the tentacle.

The length of time the specimens are preserved in formalin must also be taken into consideration. The slight acidity of formalin, which is usually used for preservation, is high enough to dissolve many spicules. The longer they are preserved the fewer spicules can be found. One specimen of *S. chloronotus*, collected at Puerto Galera in 1912, was found to possess all the different organs with the exception of the calcareous deposits. Not a single spicule was left. The color of the body became entirely bleached.

With the exception of some slight variations, the general plan of the different systems of the body is similar to those of the holothurians belonging to the same order.

Semper (1868) noted some muscular tubules traversing the connective-tissue layer of the body wall. He stated that these tubules are connected to the radial canal. Gerould (1896) found that these muscular tubules in *Caudina arenata* are direct-

ly continuous with the transverse or circular muscles of the body wall. In *S. chloronotus* these muscular tubules appear to be outgrowths of the circular muscles similar to *Caudina arenata* as found by Gerould. However, the muscular tubules in the species under discussion are found only in the dorsal ambulacral regions. They resemble regular vessels with some cells within the lumen. If these muscular tubules are true outer extensions of the circular muscles, it would be interesting to find out why the muscle fibers are arranged in the form of hollow cylinders with cells within the lumen. Gerould may be right in his explanation that these muscular tubules may be rudimentary ambulacral vessels whose central ends have lost their primitive connection with the radial canal and which become united secondarily to the transverse muscles of the body wall.

Gerould (1896) said that in *C. arenata* the longitudinal muscle fibers in the cloaca are entirely absent, while Clark (1907) stated that they are functionally replaced by about twenty isolated, irregularly arranged, small, longitudinal muscles lying outside the circular-muscle layer. In *S. chloronotus* both circular- and longitudinal-muscle layers are found. Contrary to Clark's findings, the longitudinal muscle is within the circular-muscle layer.

The arrangement of the muscle layers in the wall of the alimentary tube of *Caudina* is the same as in all Molpadiidæ and Cucumariidæ where the longitudinal-muscle fibers lie within the circular-muscle layer (Gerould, 1896). In *Holothuria* a similar arrangment of muscle layers is found in the regions of the pharynx and the stomach only. In the region of the small and the large intestine the longitudinal-muscle layer lies outside the layer of circular-muscle fibers (Hamann, 1884). In *S. chloronotus* the arrangement of the muscle layers agrees with that described by Gerould and others.

In *Cucumaria frondosa* the stomach lacks the inner connective-tissue layer (Gerould, 1896). In *C. cucumis* and *C. planci* the inner connective-tissue layer is lacking in the pharynx and insignificant in the wall of the stomach (Hamann, 1896). In *S. chloronotus,* however, the inner connective-tissue layer is present in both pharynx and stomach.

Semper (1868) found perforations at the tips of the lateral branches of the respiratory trees in *S. variegatus.* Sluiter (1887) and Hamann (1884) found similar structures in other holothurians. Kingsley (1881) and Gerould (1896) were unable to find in *Caudina* any perforation at the tips of the branches

of the respiratory trees. Repeated attempts failed to show any perforations at the tips of the respiratory branches in *S. chloronotus*.

Gerould (1896) found a single layer of muscle fibers in the muscular layer of the respiratory tree. He said that the muscle fibers run in all directions parallel to the surface. This was confirmed by Jourdan (1883) on *Cucumaria planci*. In *Holothuria tubulosa*, Semper (1886) and Hamann (1884) found two layers, corresponding to those of the intestine; namely, an inner layer of longitudinal fibers and an outer one of circular fibers. In *S. chloronotus* two layers of muscle fibers are found.

Jourdan (1883) did not recognize that the radial nerve is made up of an outer and an inner band. Hamann (1883–84) denied the existence of the connective-tissue partition between the two parts of the radial nerve cord. Semper (1868), Herouard (1887), Gerould (1896), Clark (1907), and Sedgwick (1909) recognized the inner and the outer part of the radial nerve cord. The inner part is said to be the deep oral system, and the outer is said to be a part of the ectoneural ventral system. Not all of them, however, recognized the fact that the inner part is double. Semper in his work on some holothurians showed the double parts of the deep oral system. Sedgwick (1909) mentioned it as being obscurely double. Two thin bands of the deep oral system are found in *S. chloronotus*, thus agreeing with the findings of Semper.

The five radial neural canals lying immediately below the five radial nerves were first found by Semper (1868). They were also noted by Théel (1882), Hamann (1884), Herouard (1889), Gerould (1896), Clark (1907), and others, so that the presence has been satisfactorily demonstrated throughout the whole group of Holothuroidea. These canals were called "pseudohæmal" by Hamann and "canal sous-nervien" by Herouard. Gerould proposed the term "hyponeural." Semper found that in Holothuriidæ these canals terminated blindly behind the nerve ring. The same is true in Cucumariidæ (Herouard) and in *Caudina* (Gerould). In *S. chloronotus* these hyponeural canals are also present and terminate blindly behind the nerve ring.

Similar canals are found on the outer part of the radial nerve cord and are called "epineural" by all investigators. They are generally regarded, however, as the result of an artificial separation of the external face of the radial nerve from the con-

nective-tissue layer of the body wall. Herouard (1889) and Gerould (1896), however, stated that these epineural canals are not the result of artificial breaks between the nervous and the connective tissue, but are normal cavities. In *S. chloronotus* these canals are also normal cavities as they are lined with regular epithelial cells. It is the opinion of Gerould that these canals are filled with a fluid similar to that found in the body cavity, which possibly protects the nervous system against injuries incident to violent contractions of the body wall.

SUMMARY

Stichopus chloronotus Brandt, collected from Puerto Galera, Mindoro, and Hundred Islands, Pangasinan Province, Luzon, Philippine Islands, ranges from 200 to 400 millimeters in length. It is deep blue or almost black, with the tips of the papillæ slightly lighter in color. Usually it has twenty tentacles, but sometimes it may have eighteen or nineteen. Its calcareous deposits are C-shaped, rosette, simple and complex tables, simple or branched rods, large quadrangular supporting rods, and supporting sieve plates.

The body wall consists of five parts; namely, the epidermis, the connective-tissue layer, the circular-muscle layer, the longitudinal radial muscles, and the lining epithelium. The body cavity is incompletely traversed by three mesenteries, which suspend the three coils of the alimentary canal.

The water-vascular system is made up of the circular canal, the five radial canals, the tentacular and ambulacral canals with their ampullæ, the stone canal, and the madrepore body. The madreporite opens by numerous pores to the body cavity, thus making the fluid contents of the water-vascular system and that of the body cavity identical with each other.

The alimentary canal is composed of mouth, pharynx, stomach, small and large intestines, cloaca, and anus. The stomach, the small intestine, and the large intestine are not distinctly marked off from each other. Histologically, the wall of the alimentary canal consists of five layers, as follows: An outer layer of epithelium, a thin outer layer of connective tissue, a muscular layer composed of circular- and longitudinal-muscle fibers, a thick inner layer of connective tissue, and a lining epithelium.

The respiratory system is composed of two respiratory trees, which arise from a short common trunk on the anterior dorsal part of the cloaca. The left one is in close relationship with the

blood plexus of the dorsal, intestinal, hæmal vessel. The respiratory tree is an outgrowth of the intestine, and it is histologically similar to it.

The principal parts of the hæmal, or blood, system are the pharyngeal blood ring, the dorsal and ventral intestinal vessels, the radial perihæmal canals, and the lacunar spaces. The pharyngeal blood ring is posterior to the water circular canal. The two intestinal vessels are distinct from each other and are connected with the lacunar spaces of the alimentary canal by rete mirabile.

The reproductive system consists of a genital duct and tufts of genital tubules. The duct opens to the exterior in the mid-dorsal interradius about 10 millimeters behind the tentacles. The wall of the gonads is made up of peritoneal epithelium, a thin layer of circular-muscle fiber, a layer of connective tissue, and an inner germinal epithelium. The sexes are always separate.

The nervous system is divided into the ectoneural ventral system and the deep oral system. The first consists of a circumoral nerve ring, which gives rise to the tentacular and buccopharyngeal nerves, and to five radial nerve cords with branches to the tube feet, the papillæ, and the integument. The second is composed of double radial nerve bands closely applied to the radial nerve cord of the ectoneural ventral system. The principal sense organs are the tentacles, although some sensory nerve cells are found scattered all over the covering epithelium of the body.

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ILLUSTRATIONS

PLATE 1

FIG. 1. *Stichopus chloronotus* Brandt, dorsolateral view.
go, genital opening.
t, tentacles.
tf, tube feet.
dlp, dorsolateral papillæ.
vlp, ventrolateral papillæ.
dia, dorsal interambulacrum.
lia, lateral interambulacrum.
an, anus.

2. *Stichopus chloronotus* Brandt, anteroventral view.
t, tentacle.
op, oral papilla.
st, stalk of tentacle.
m, mouth.
p, papilla.
tf, tube feet.
via, ventral interambulacrum.

3. *Fierasfer homei* Richardson, lateral view. This fish is commensal with *S. chloronotus*.

Plates 2 to 11 illustrate the internal anatomy of *Stichopus chloronotus* Brandt.

PLATE 2

FIG. 1. Large straight quadrangular rod; actual length, 796 microns.
2. Large curved quadrangular rod; actual length, 647 microns.
3. Small curved quadrangular rod; actual length, 185 microns.
4. Small straight quadrangular rod; actual length, 92 microns.
5. Side view of large table with four pillars; actual height, 74 microns.
6. Ventrolateral view of large table with six pillars; actual height, 111 microns.
7. Dorsolateral view of large table with six pillars; actual height, 56 microns.
8. Dorsal view of large table with six pillars, actual diameter of edge, 56 microns.
9. Lateral view of large table with six pillars; actual height, 148 microns.
10. Small sievelike rosette; largest diameter, 33 microns.
11. Large sievelike rosette; largest diameter, 44 microns.
12. Simple incomplete rosette; actual length, 130 microns.
13. Rosettelike spicule; actual width, 37 microns.

14. Simple incomplete rosette; actual size, 37 microns.
15. Simple incomplete rosette; actual length, 37 microns.
16. Small sievelike rosette; largest diameter, 37 microns.
17. Simple rosette; actual length, 37 microns.
18. Simple rosette; actual length, 37 microns.
19. Rodlike spicule; actual length, 93 microns.
20. Simple incomplete rosette; actual length, 56 microns.
21. Wrenchlike spicule; actual length, 93 microns.
22. Lateral view of a simple table found in the body wall; actual height, 37 microns.
23. Modified simple table from the same region as fig. 22.
24. Same as fig. 23, seen from a different angle; actual height, 37 microns.
25. Lateral view of a simple table with short pillars; actual height of pillars, 20 microns.
26. Dorsal view of a simple table (compare fig. 22); actual width, 30 microns.
27. Base of a simple table (compare fig. 23); actual width, 37 microns.
28. More complex form of a base of a simple table; actual width, 37 microns.
29. Base of a simpler form of a simple table; actual width, 37 microns.
30. C-shaped spicule of body wall; actual length of its longest axis, 37 microns.
31. Variation of C-shaped spicule of body wall.

PLATE 3

FIG. 1. Supporting sieve plate at the margin of the tips of tube feet; actual measurement in its longest diameter, 252 microns.
2. Supporting sieve plate at the central portion of the tips of tube feet; actual diameter, 222 microns.
3. Branched spicule from the gonad; actual length, 92 microns.
4. X-shaped spicule from the gonad; actual height, 111 microns.
5. Rodlike spicule from the gonad; actual length, 111 microns.
6. Small rod-shaped spicule from the suspensor of the pharynx; actual length, 37 microns.
7. Variation of fig. 6; actual length, 63 microns.
8. Variation of fig. 6; actual length, 92 microns.
9. Variation of fig. 6; actual length, 92 microns.
10. Rod-shaped spicule from the walls of the alimentary canal; actual length, 130 microns.
11. Branched spicule from the walls of the alimentary canal; actual length, 130 microns.
12. Rod-shaped spicule from the walls of the alimentary canal; actual length, 111 microns.
13. X-shaped spicule from the walls of the alimentary canal; actual height, 99 microns.
14. Y-shaped spicule from the walls of the alimentary canal; actual length, 130 microns.

15. Forked spicule from the walls of the alimentary canal; actual length, 148 microns.
16. Spinous supporting rod of tube feet with sieve-plated ramifications at the middle; actual length, 333 microns.
17. Variation of fig. 16; actual length, 333 microns.
18. Variation of fig. 16, with simple branch at the middle; actual length, 300 microns.
19. Variation of fig. 16, with spinous processes at the middle; actual length, 350 microns.
20. Portion of calcareous ring showing a radial piece and interradial pieces; acual height of the radial piece, 10 millimeters.
21. Interradial piece of calcareous ring; actual height, 5 millimeters.

PLATE 4

FIG. 1. Small portion of a cross section of an ovary.
eth, external epithelium.
cm, circular muscle layer.
ct, connective tissue.
ge, germinal epithelium.
fc, follicular cell.
2. Cross section of a blood vessel.
eth, external epithelium.
m, indistinct muscle layer.
cs, connective-tissue strand.
sc, spheruliferous corpuscle.
bc, blood cell.
3. Cross section of a small part of the hæmal-respiratory-tree plexus showing the intimate relationship between the vessel and the minute branches of the tree.
bv, blood vessel.
wc, wandering cell.
sp, respiratory-tree branch.
4. Cross section of testis.
eth, external epithelium.
cm, circular muscle.
gc, germ cells in their early stages of spermatogenesis.
ct, connective tissue.
ge, germinal epithelium.
sc, spermatozoön.
5. Small complex rosettelike spicule from the trunk of the respiratory tree; actual diameter, 110 microns.
6. Large complex rosettelike spicule from the trunk of the respiratory tree; actual diameter, 190 microns.

PLATE 5

FIG. 1. Inner surface of the calcareous ring, circular water canal, and its branches.
t, tentacle.
st, stalk of tentacle.
tn, tentacular nerve.

nr, nerve ring.
cr, calcareous ring.
mp, madreporite.
sc, stone canal.
pv, Polian vesicle.
rwc, radial water canal.
twc, tentacular water canal.
ta, tentacular ampulla.
mrw, main radial water canal.
cwc, circular water canal.
pr, pharyngeal blood ring.

2. Small section of the pharynx and the pharnygeal blood ring.
ie, internal epithelium.
sp, suspensor of the pharynx.
s, spicule.
ps, peripharyngeal sinus.
pr, pharyngeal blood ring.
pw, communication between pharyngeal blood ring and water canal.
bc, blood cells.
wc, circular water canal.
pvo, opening of Polian vesicle into circular water canal.
pv, Polian vesicle.
p, wall of pharynx.

PLATE 6

A specimen opened along the dorsal interambulacrum showing the general anatomy.
t, tentacle.
ta, tentacular ampulla.
cr, calcareous ring.
m, madrepore body.
s, suspensors.
sc, stone canal.
cw, circular water canal.
pr, pharyngeal blood ring.
pv, Polian vesicle.
gd, genital duct.
bw, body wall.
g, gonad.
rt, right respiratory tree.
rw, radial water canal.
lm, longitudinal muscle.
cm, circular muscle.
ct, common respiratory-tree trunk.
cl, cloaca.
p, papilla.
tf, tube feet.
lt, left respiratory tree.
rhp, respiratory-hæmal plexus.

cs, connective strands.
a, anus.
s, stomach.
si, small intestine.
li, large intestine.
dv, dorsal intestinal hæmal vessel.
vv, ventral intestinal hæmal vessel.
cv, cross-ventral intestinal hæmal vessel.

PLATE 7

FIG. 1. Cross section through the radial nerve cord and its accompanying vessels.
lm, longitudinal muscle.
rs, radial blood sinus, or perihæmal sinus.
rw, radial water canal.
hc, hyponeural canal.
rni, inner band of the deep oral system.
rno, outer nerve band of the deep oral system.
rne, radial nerve cord of the ectoneural ventral system.
ep, epineural canal.
ce, cœlomic epithelium.
ct, connective tissue.
lc, lacunar space.
cm, circular muscle layer.

2. Longitudinal section of a small portion of the tip of the tentacle.
e, epithelium composed of mostly supporting and sensory cells.
sc, spheruliferous corpuscle.
tc, part of the tentacular canal.
lm, longitudinal muscle.
ct, connective tissue.

3. Inner surface of one ambulacrum showing the longitudinal muscle and its relation to the radial piece of the calcerous ring.
rw, radial water canal.
tc, tentacular canal.
cr, calcareous ring.
lm, longitudinal muscle.
cm, circular muscle.
s, sphincter.

PLATE 8

FIG. 1. Fragment of the calcareous ring; actual length, 74 microns.
2. Variation of fig. 1; actual length, 150 microns.
3. Variation of fig. 1; actual length, 111 microns.
4. Variation of fig. 1; actual length, 37 microns.
5. Variation of fig. 1; actual length, 150 microns.
6. Variation of fig. 1; actual length, 150 microns.
7. Small portion of the large intestine, showing the intestinal appendages caused by a parasite.
iw, intestinal wall.
ia, intestinal appendage.
dv, dorsal intestinal hæmal vessel.

8. Longitudinal section of one mature intestinal appendage.
    ot, wall of outer tubule.
    it, wall of inner tubule.
    eo, embryolike organism.
    gr, granules.
    ac, amœboid cell.
    wc, wandering cell.
    mc, mesenchyme cell.
9. Oval corpuscle from the wall of the alimentary canal; actual length, 18.5 microns.
10. Variation of fig. 9, from the body wall; actual length, 30 microns.
11. Sensory cell from the tentacle; actual length, 18 microns.
12. Similar cell from the body wall; actual length, 18 microns.
13. Supporting cell from the tentacle; actual height, 25 microns.
14. Supporting cell from the body wall; actual height, 20 microns.
15. Spheruliferous corpuscle from the body wall; actual length in its longest axis, 22 microns.
16. Spheruliferous wandering cell from the body wall; actual length, 37 microns.
17. Blood corpuscle; actual diameter, 3 microns.
18. Variation of fig. 17; actual diameter, 3 microns.

PLATE 9

Diagram of the cross section of the body wall through the median ventral ambulacrum.
    cm, circular muscle.
    lm, longitudinal muscle.
    ep, epineural canal.
    rw, radial water canal.
    rni, inner nerve band of the deep oral system.
    rno, outer nerve band of the same system.
    rnc, radial nerve cord of the ectoneural ventral system.
    rs, radial blood sinus.
    hc, hyponeural canal.
    v, valves of the opening of the radial water canal into an ambulacral canal.
    ac, ambulacral canal.
    pn, pedal nerve.
    ce, cœlomic epithelium.
    pa, pedal ampulla.
    ed, epidermis.
    ct, connective tissue.
    st, simple table.
    sc, spheruliferous corpuscle.
    sp, C-shaped spicule.
    pm, pedal longitudinal muscle.
    pc, pedal canal.
    sp, section of supporting sieve plate.
    sr, section of supporting spinous rods.

PLATE 10

FIG. 1. Low-power drawing of the cross section of a respiratory-tree trunk.
lb, lateral branch.
ee, external epithelium.
cm, circular muscle.
lm, longitudinal muscle.
ct, inner connective-tissue layer.
oct, outer connective-tissue layer.
ie, internal epithelium.
sp, section of rosettelike spicule.

2. Small portion of a cross section of the intestine showing a bud of the intestinal appendage.
lm, longitudinal muscle.
ia, intestinal appendicular bud.
ee, external epithelium.
oct, outer connective-tissue layer.
cm, circular muscle.
ict_1, outer vacuolated and reticular part of the inner connective-tissue layer.
ict_2, inner homogeneous fibrous part of the inner connective-tissue layer.
ie, internal epithelium.
sc, spheruliferous corpuscle.

3. Cross section of the circular water canal.
c, cilia.
ie, internal epithelium.
cm, circular muscle.
ct, connective tissue.
ee, external epithelium.
wc, wandering cell.
sp, rodlike spicule.

4. Longitudinal section of a small part of the body wall through the longitudinal-muscle band.
ce, cœlomic epithelium.
lm, longitudinal muscle.
cs, connective-tissue strand.
lc, lacunar space.
cm, circular muscle.
ct, connective tissue.

5. Cross section of the stone canal.
dm, part of dorsal mesentery.
ce_1, columnar internal epithelium.
ce_2, cuboidal internal epithelium.
c, cilia.
cb, calcareous bodies.
ct, connective tissue.

6. Small portion of a cross section of the cloaca.
cs, connective-tissue strand.
ee, external epithelium.

oct, outer connective-tissue layer.
cm, circular muscle.
lm, longitudinal muscle.
ct, inner connective-tissue layer.
ie, internal epithelium.
sc, spheruliferous corpuscle.
cc, connective-tissue cell.

PLATE 11

Longitudinal section of madrepore body.
ch, chamber of the madrepore body.
c, cilia.
ee, external epithelium
p, pore.
stc, stone canal.
dm, dorsal mesentery.
cb, calcareous bodies
ct, connective tissue.

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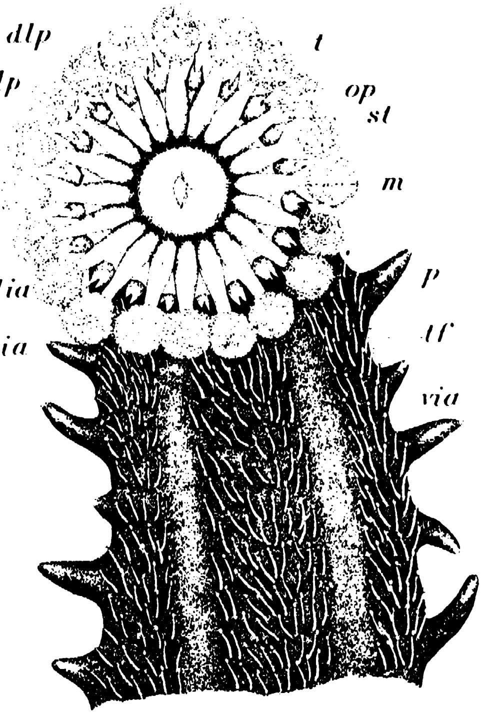

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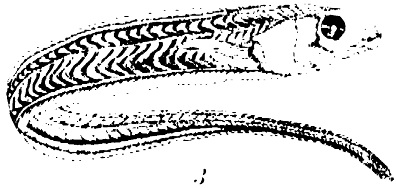

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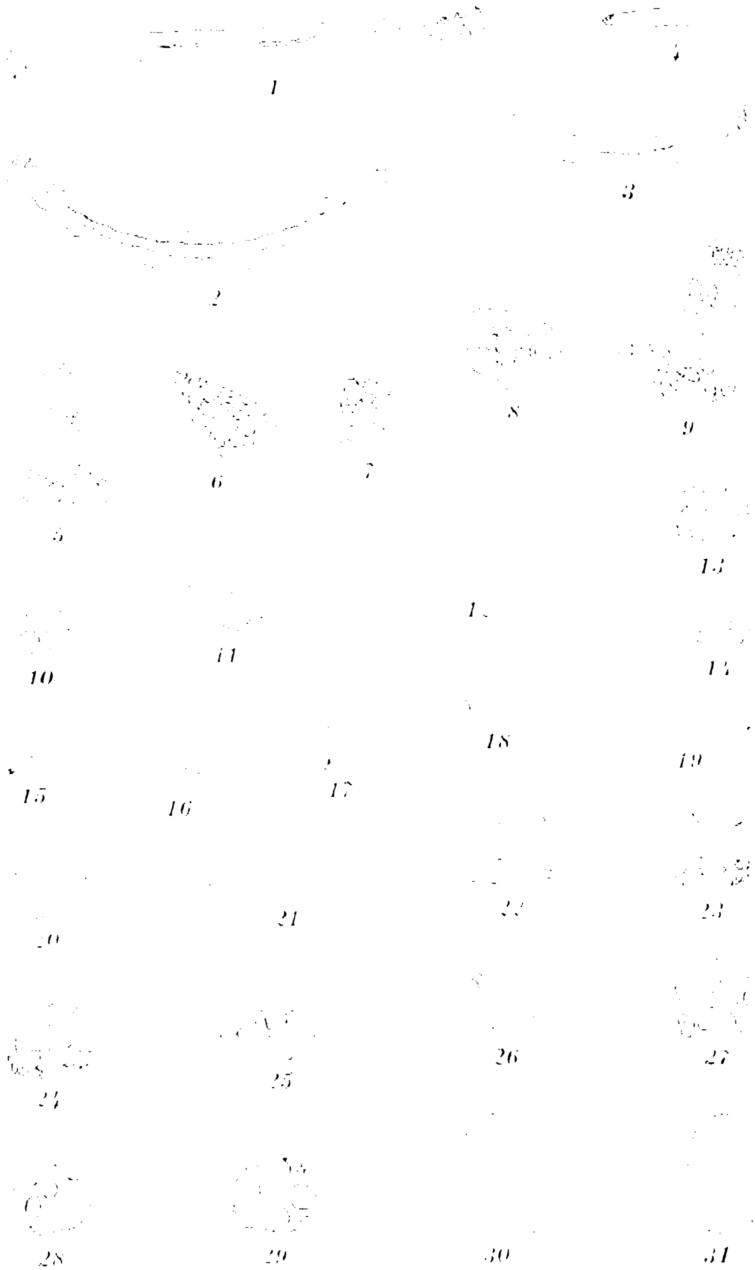

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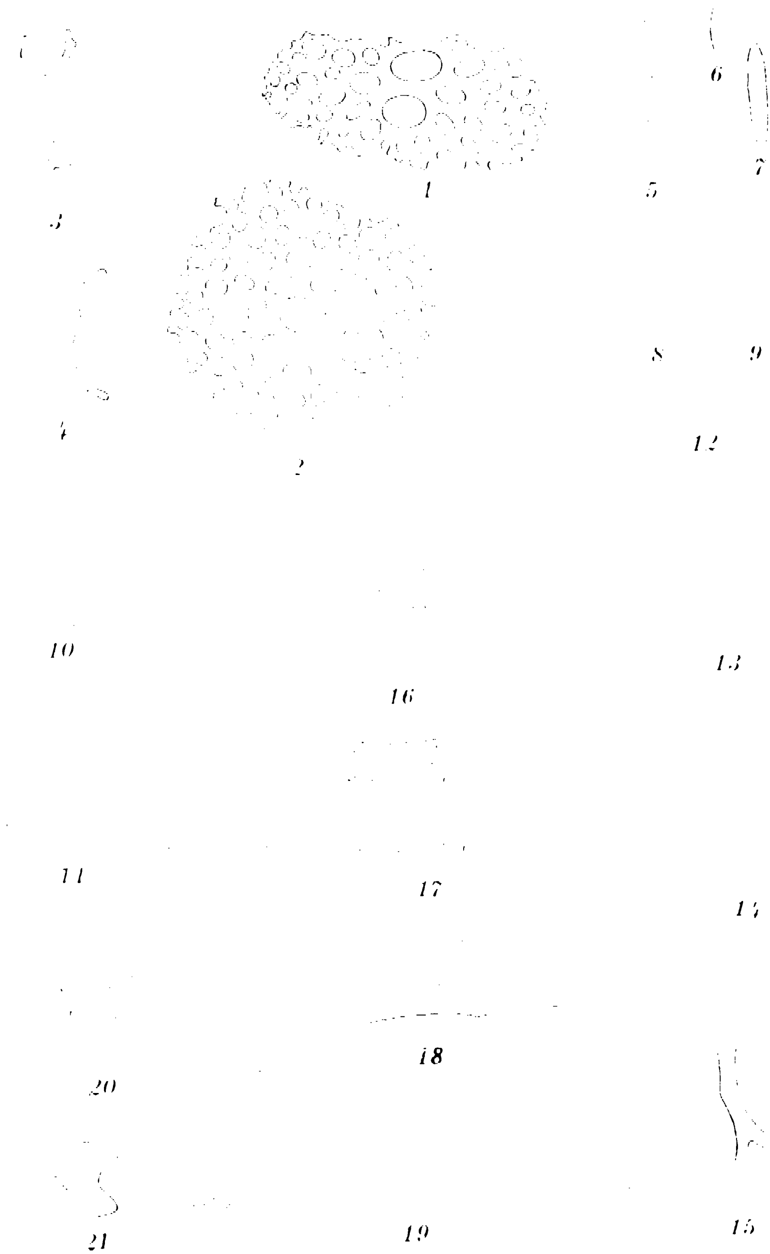

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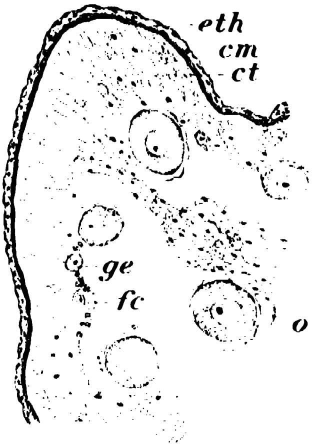

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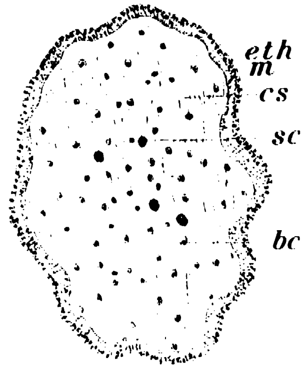

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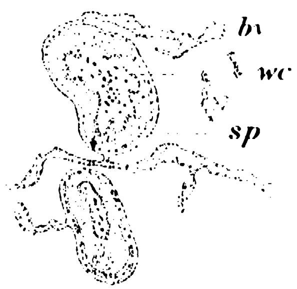

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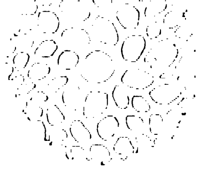

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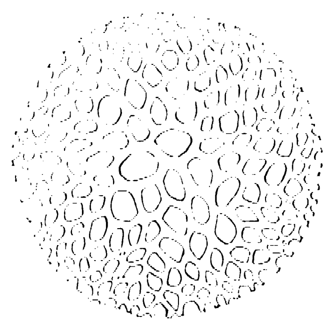

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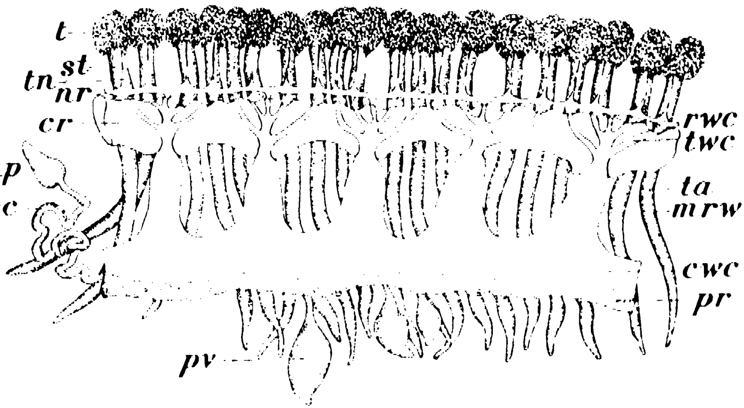
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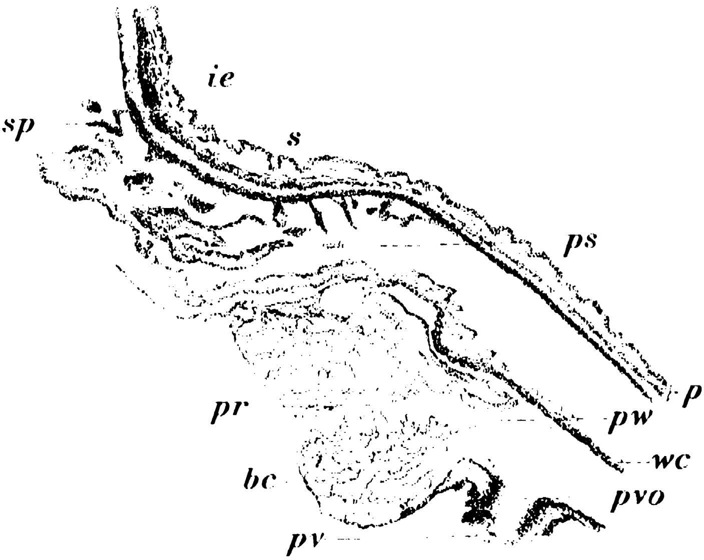
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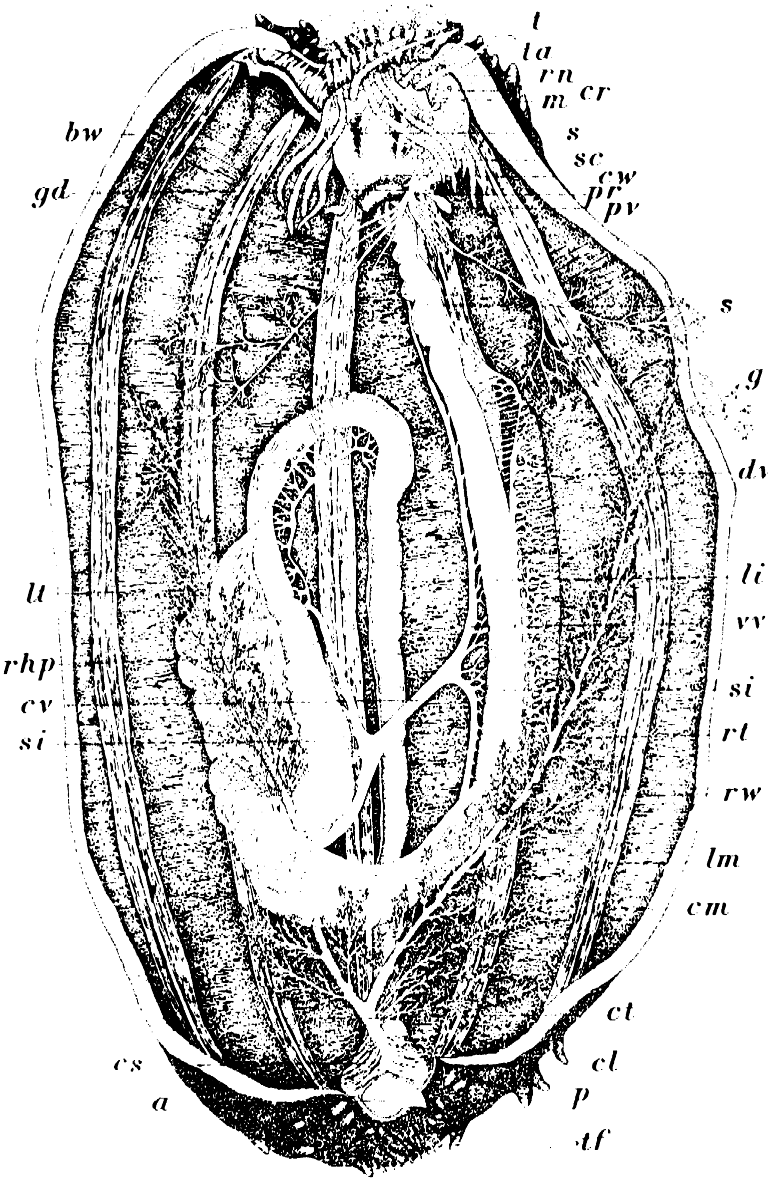
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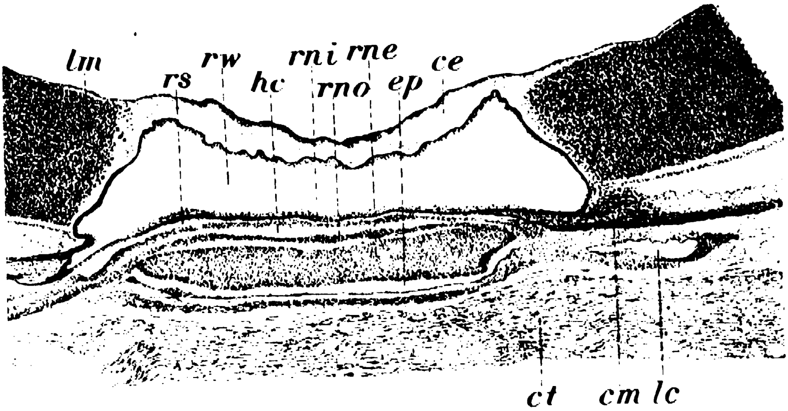

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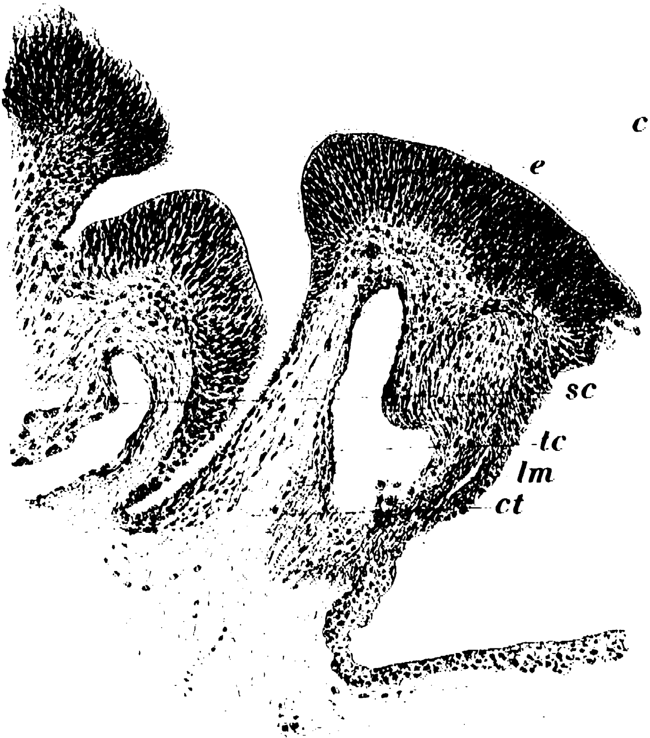

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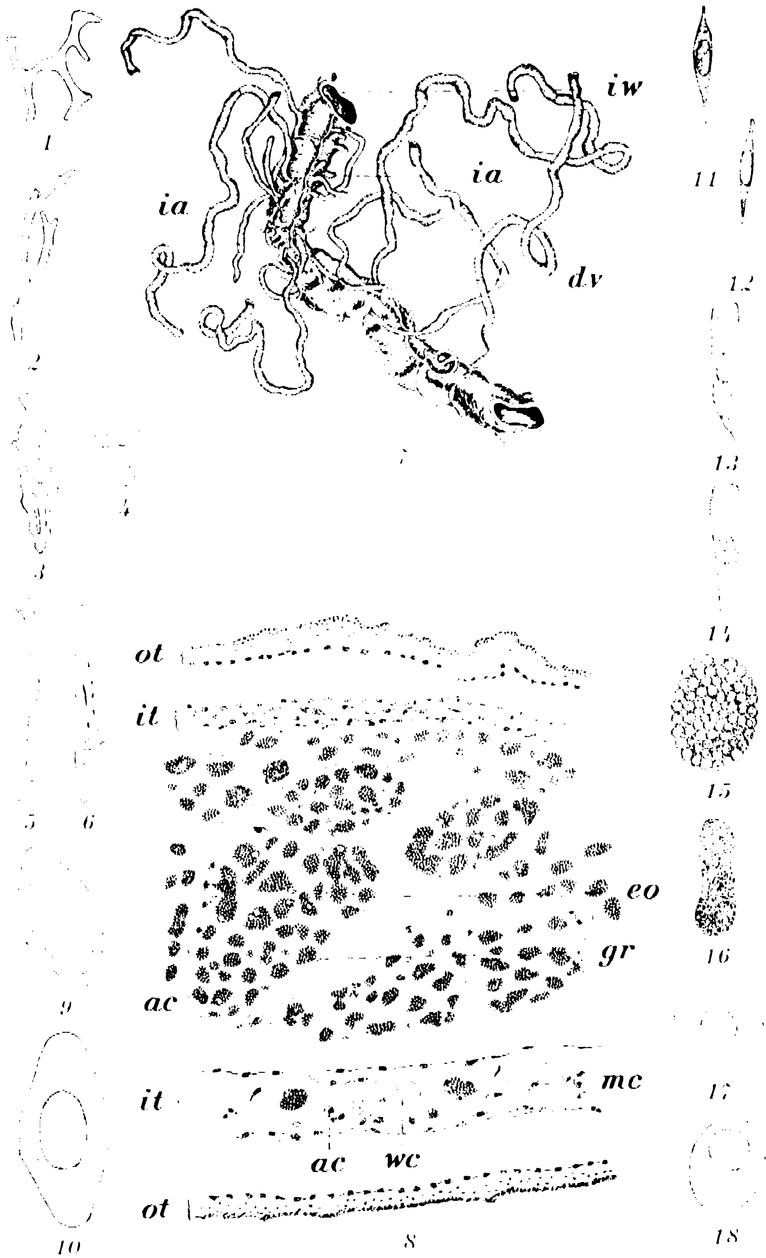
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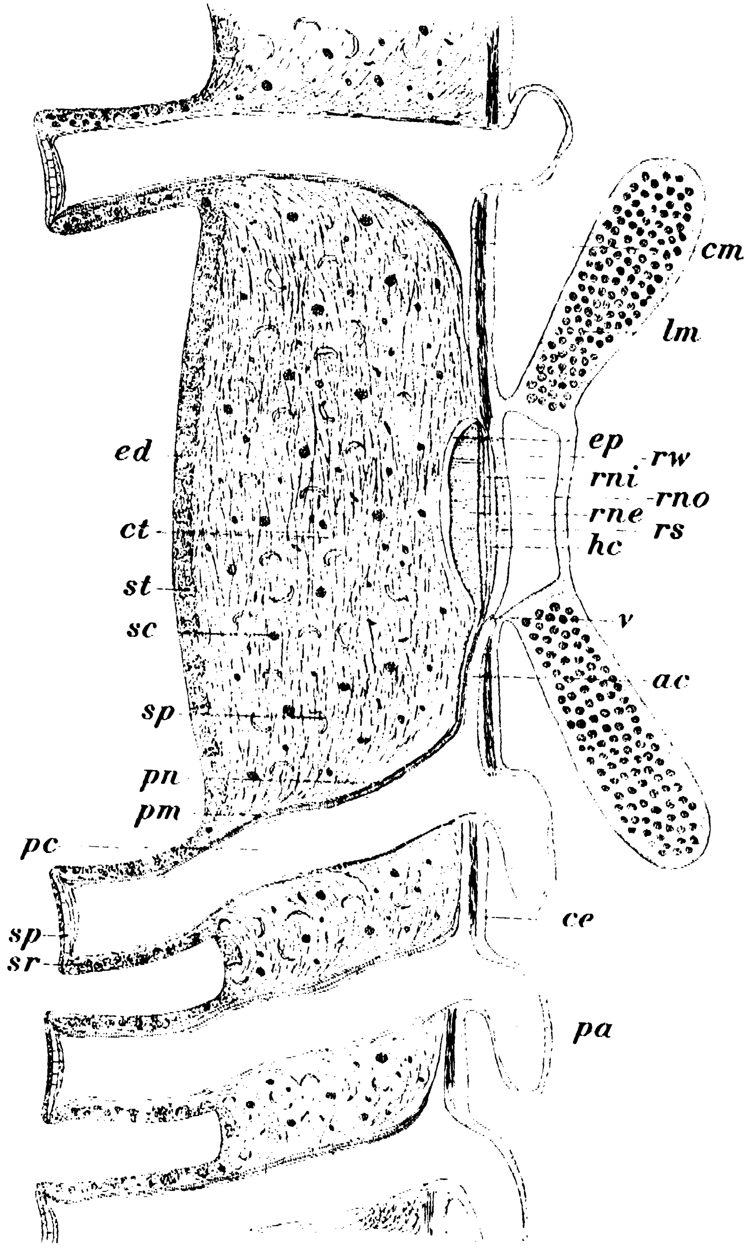

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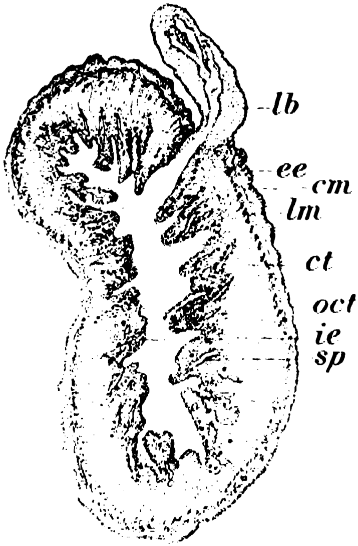

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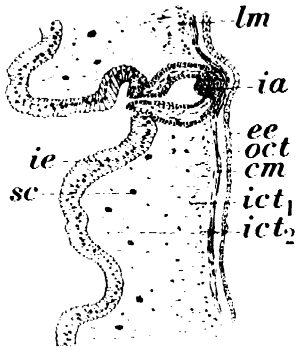

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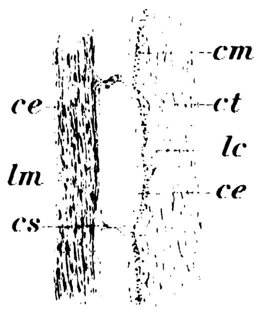

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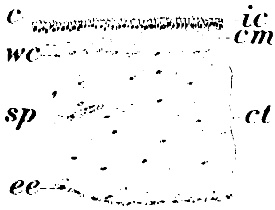

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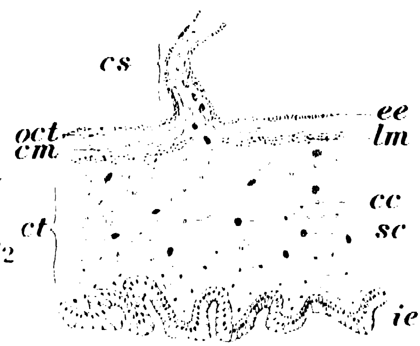

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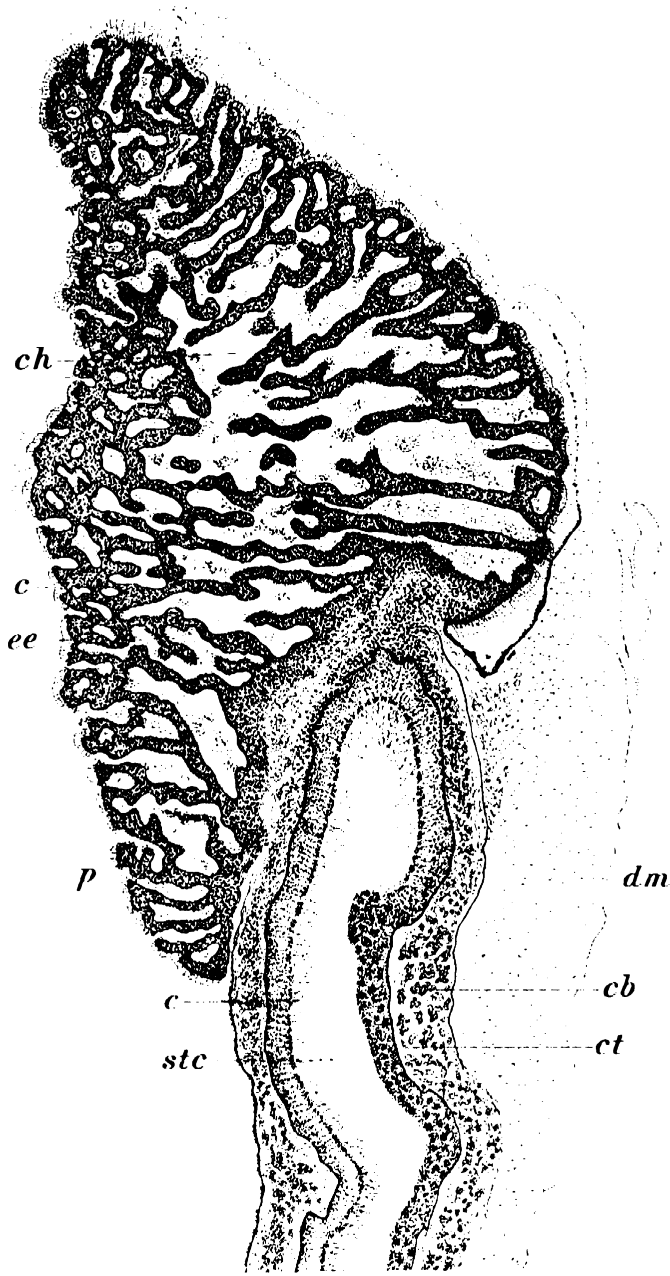


PLATE 11.

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 37 DECEMBER, 1928 NO. 4

LEPTOCHILUS AND GENERA CONFUSED WITH IT

By EDWIN BINGHAM COPELAND
Of Chico, California

THIRTY-TWO PLATES AND FIFTY-TWO TEXT FIGURES

The reaction from the purely descriptive attitude in fern taxonomy, exemplified by the genus *Acrostichum* of Hooker's Species Filicum and the Synopsis Filicum of Hooker and Baker, found its first general expression in the treatment of the Polypodiaceæ by Diels in the Natürlichen Pflanzenfamilien. Many of the natural genera found independent places in this work, but a large and unnatural genus *Gymnopteris* still survived. In Christensen's invaluable Index this was practically unchanged except in name, becoming *Leptochilus*. The purpose of the present study is the recognition of the natural groups still combined here in the two great works just referred to, and a monographic treatment of some of the natural genera. It is nearly a quarter of a century since I began to recognize these natural groups, describing *Christiopteris*, reviving *Lomagramma*, and accepting *Hemigramma*. I was singularly slow to comprehend the identity of *Campium*; and, until this was done, any comprehensive analysis was impossible. It is not presumed that this presentation is perfect, but it is confidently believed that it is a closer approximation to nature than were any of its predecessors.

A work of this kind has two somewhat distinct phases. One is acquaintance with the ferns. As the words reasonably may be understood, I know the Philippine species well; which is a particular advantage in work with these groups, because several

of the critical problems demand just this knowledge for their solution. I know the Indian ferns from copious herbarium material; their treatment is, therefore, such as any botanist might prepare, if previously familiar with the genera. I know the African species only from scanty herbarium material; and treat them at all only because failure to do so would be likely to make the rest of the work less useful, the African and the Oriental species being congeneric.

Because of a similar lack of familiarity with them, the American ferns of late called *Leptochilus* are not considered. This only needs to be clear with regard to them: they are not, collectively, congeneric with the Old World species. I do not state that no American species represents an Old World genus, but the Old World acrostichoid genera in question have been evolved in the Old World from Old World ancestors with definite sori; and I know no evidence—such as we have, for example, in *Plagiogyria* and *Didymochlaena*—that any of these younger genera have succeeded in crossing either the Pacific or the Atlantic Ocean. I do know that, as will be pointed out presently, at least a part of the American so-called *Leptochilus* species have exclusively American non-acrostichoid relatives.

The other phase of a work of this kind is the determination of the proper generic and specific names.

In the course of this study a remarkable succession of nomenclatorial complications has been encountered. These will be noted as they arise, but merit some attention by themselves. It seems to be a common belief that the botanists of the world follow one or the other of two sets of rules, but the fact is rather that most botanists try to do so. It is a fairly unanimous doctrine to-day that a species, in literature, must be established by its description, and that a genus must have a type or standard species; the usual way of selecting this species, when the author of the genus has not done so specifically, is to choose the first one listed by him. The proposition that a species must be typified by a specimen is approaching unanimous acceptance in current practice. Without first going into more detail, let us try to apply the foregoing.

The case of *Leptochilus* itself is clear-cut. It was monotypic, and the identity of this type species has never been questioned. The trouble begins with the selection of generic names for the heterogeneous ferns that recent writers have called *Leptochilus*.

The oldest, if not most venerable, among the candidate names for the many ferns recently but improperly called *Leptochilus*

is *Poikilopteris*, accredited to Eschweiler, as of 1827. The "publication" is in a review, signed in parenthesis, and reads:

> Die Synonymie ist hier sehr vervollständigt, die Fragweise angeführten können wir meist bestätigen, vorzüglich die Preslschen Synonymen: so ist *Acr. scandens* Raddi allerdings *Acr. fraxinifolium* Presl, doch haben beid nur den alternden Zustand beschrieben, da diese Pflanze eine neue sehr ausgezeichnete Gattung ist welche wir *Poikilopteris* nennen . . . .

In spite of Presl's qualified, and Underwood's[1] unqualified judgment, I agree with Christensen, that this was no valid publication, and that this genus, if recognizable, must date from Presl, Tent. Pterid. (1836) 241. It is then unnecessary to determine its type species, as it is antedated for American ferns by *Bolbitis* Schott, and for the Oriental ones by *Campium*. *Bolbitis* is derived from *Phlebodium;* as to this I believe that anybody can satisfy himself by comparing the paleæ and venation of *Bolbitis serratifolia* with those of *Phelbodium aureum*. As neither *Bolbitis* nor *Phlebodium* has a known representative in the Old World, I am not further concerned with them here.

The next name in point of priority is *Campium* Presl, Tent. Pterid. (1836) 238. It is well described, by text and by figure, and the fact that I construe it now as including the Oriental ferns called *Poecilopteris* by Presl, and also the same author's genus *Dendroglossa*, has nothing to do with its validity. For Presl, as for us, the genus was a group of species—similar species, for him; related species, for us. Our demand, that beside description, illustration, and the citation of a number of species, the genus be further exemplified by one species as its type, surely never occurred to him or to his contemporaries as a possible one. The first species mentioned, in the body of the diagnosis, is *Campium punctulatum*, followed in the same sentence by *C. costatum*. Following the diagnosis and a discussion, there is a list of species, headed by the same two. Ostensibly, the type species should be the plant, whatever it was, there meant by *C. punctulatum*, but two questions then arise: What is the plant? What should it be called?

It is identified by Presl as "Acrostichum punctulatum *Presl nec Lin.*" It did not wait for the moderns to raise the point that an invalid name could not be transferred; Fée,[2] without formulating his reasons, provided a new name, *Heteroneuron preslianum*, citing Presl. Incidentally, he presented a diagnosis, drawn, not from Presl's fern, which he clearly never saw, but from a rare

[1] Mem. Torrey Bot. Club 6 (1899) 272. [2] Acrost. 92.

fern of southern India. As it happens, Presl was flattered enough to accept this as a correction, and even to support it by the wild guess that "Asia" on Hügel's label (Fée's fern) was "Verisimiliter quoque Manila." Otherwise, Presl's specific name might be retained, on the hypothesis that he knew as well as Fée that is was not subject to transfer, but, still liking the name, administered it again, de novo. To deny this possibility is to maintain that this one nameless plant could not be given a name which could be given to any other nameless plant in the genus.

Being acquainted with the Indian fern described by Fée, from the examination of specimens confidently referred to it, and this identification checked by a photograph of the Vienna specimen cited and seen by Fée, and knowing neither this fern nor any near relative of it in the Philippines, but knowing in the Philippines ferns in another genus that are superficially very much like it, I have grave misgivings as to this generic type. I have tried in vain to clear this question, by inquiry as to Presl's type specimen, understood to be in Prague.

There is no question as to Presl's idea of his genus *Campium*, nor as to any other of the five species he cites. Before, in, and after his time, a genus was a group, as a whole, properly described as a whole, never expected to rest, for validity or for identification, upon any single species. Under the circumstances, I would be unable to justify any other course than the choice of *Campium*, as the name of the large genus that includes all of the species to which Presl gave the name, except, perhaps, the one which he chanced to mention first; but, to secure the exact embodiment of the generic idea that modern workers have found desirable and eventually necessary, I propose that *Campium costatum*, with the proper Wallich type, be recognized as the standard species of the genus.

Although none of the other generic names is in question, a multitude of nomenclatorial difficulties and puzzles will demand attention in the course of this work. I have disposed of them as best I could. To make revision easy in the future, in case my decisions are questioned, I am presenting the literature, rather completely. As practically always happens in a work of this kind, I have felt obliged to increase the number of species demanding recognition. As likewise usually happens, I regard some hitherto accepted species as identical with one another. Additions and reductions will of course continue in the future. To facilitate such activity, I have tried to assemble here the most

critically important literature—in particular, the original diagnoses of the species. These require no more space than would new descriptions. Where the diagnoses are very defective, I have added to them, but I have not thought it necessary that I repeat them in English. Where I suspect synonymy, I quote the later-published diagnosis, without transfer of name. Any successor able to decide that he has, or has not, to deal with a synonym, will find the requisite literature references assembled here—he has only to be sure that he knows the ferns. Where reasonably certain of synonymy, I let this be the time for a name to retire; citing it sometimes, but not usually using space to repeat synonymy already published in the Index Filicum. Original diagnoses are authoritative in text, as is never true in any like sense of descriptions by later writers; and, as a rule, they also give the type localities and, explicitly or by easy inference, show where type specimens can be consulted. While correct assignment to genus is the item of first importance in the description of a species, the generic diagnosis has no corresponding importance. In assigning a species to a genus, the essential problem is the recognition of affinity. Conformity to a generic diagnosis is important to exactly the extent that it may establish affinity; in the cases of the great majority of the genera of ferns, conformity to original diagnosis hardly does this at all.

Beside the recognition of the genera, the compilation of the literature, and the application of this to the ferns, and the description of new species, I have, in *Campium* (the only genus large enough to make the discriminataion of the species very difficult), facilitated their recognition by numerous drawings of the detail of the venation, and have had photographed all new species and a number of old ones not hitherto illustrated. The drawings, in the cases of species with large, pinnate fronds, all show the venation more or less in the middle of the acroscopic side of the larger, but not the basal, pinnæ. Therefore, they are fairly comparable. Some variation of the design occurs, of course, in all species; and the pattern is necessarily different where the pinna is more deeply cut, as it often is near the base, and where it is narrower, as near the apex.

In the direct preparation of this paper, I have had the excellent library facilities of the University of California, with occasional assistance from the John Crerar Library, Harvard and Stanford Universities, the United States Department of Agriculture, and the California Academy of Science. The ferns studied are (1)

in my own herbarium; (2) in the collections deposited at the University of California by Dean Merrill; (3) large collections loaned by the Royal Botanic Gardens (Kew) and (4) the Gray Herbarium; (5) the Praeger collection of the California Academy of Science; (6) the ferns of these genera in the herbarium of the Missouri Botanical Garden; and (7), received shortly before the paper was completed, one hundred seventy specimens from the United States National Herbarium. For this generous and various assistance I wish to express grateful appreciation to those who have rendered it. The personal assistance of Dr. Carl Christensen is acknowledged at the end of this treatise.

Except as error is responsible for the inclusion of species (as *Leptochilus celebicus*, which is a *Dryopteris*), the Oriental genera represented in *Leptochilus* of the Index Filicum may be distinguished as follows:

Key to the Oriental genera represented in Leptochilus of the Index Filicum.

1. Scandent or epiphytic.
 2. Fronds simple and entire, thin .... *Leptochilus.*
 2. Fronds cleft or divided, coriaceous .... *Christiopteris.*
 2. Fronds compound, pinnæ or pinnules articulate .... *Lomagramma.*
1. Terrestrial.
 2. Rhizome creeping .... *Campium.*
 2. Rhizome short, more or less erect.
  3. Stipe scaly, not hairy .... *Hemigramma.*
  3. Stipe and frond hairy .... *Quercifilix.*

Of these genera, *Christiopteris*, *Lomagramma*, and *Hemigramma* have been accepted by Christensen, who abstains only as a matter of form from the transfer of their species. Nothing needs now to be added to my last statement on *Christiopteris*,[3] except to repeat that *C. copelandi* is not distinct from *C. sagitta*, and to question the transfer to his genus of *Polypodium cantoniense*. In the case of *Lomagramma*, also, all valid known species are already provided with proper names. The same is obviously true of *Leptochilus*, but its isolation has to be justified.

Genus LEPTOCHILUS Kaulfuss

Leptochilus KAULFUSS, Enum. Fil. (1824) 147.

A genus of polypodiid ferns, related to *Phymatodes*, as shown by the epiphytic habit, vestigial articulation of stipe to scandent, scaly but glabrescent rhizome, and reticulate venation with co-

[3] Philip. Journ. Sci. § C 12 (1917) 331.

pious and irregular free included veinlets ending in hyaline dots; further characterized by simple, entire fronds, the fertile ones narrowly linear, with acrostichoid fructification.

LEPTOCHILUS AXILLARIS (Cavanilles) Kaulfuss. Plate 1.

Acrostichum axillare CAVANILLES, Anal. Hist. Nat. 1 (1799) 101.

Acrostichum axillare caulescens, foliis sterilibus lanceolatis; fructiferis linearibus, ad sterilia subaxillaribus. *Anales pag. 101.*

El tallo crece como cinco pies, vestido de hojas estériles y fructiferas. Las estériles son lanceoladas, enteras, lampiñas, de seis pulgadas de largo con una de ancho y peciolos cortos. Las fructíferas son mas largas, de una línea de ancho, pecioladas, cuyos peciolos nacen de los de las estériles. El tegumento es muy angosto, y las cajitas ferrugíneas. Se cría en los terrenos secos de la isla de Luzón, donde lo vió el citado Née.—CAVANILLES, Descripción de las plantas, page 239.

This genus has had a career in the hands of pteridologists, more adventurous even than most of the genera of ferns with acrostichoid fructification. By 1846 it was already "nimis extensum" in Kunze's opinion. In the hands of Hooker and Baker and those under the sway of their prestige, it has of course been reduced to *Acrostichum*, or at least to *Gymnopteris*. From this dumping ground it was extracted with undue glory. In Christensen's Index, animated as it is with the spirit of phylogeny, *Leptochilus* is made to include ferns as diverse as *Hemigramma*, tectarid in origin; *Christiopteris*, probably matonioid; *Lomagramma*, remotely dennstaedtioid; a lot of unrelated American ferns; and several dozen more nearly related terrestrial species of its own part of the world.

Leptochilus itself is almost certainly related to the *Phymatodes* section of *Polypodium*; more especially, probably, to the group of *Polypodium myriocarpum*.[1] The tendency to lose the individuality of the sori is shown in this group by another offshoot, *Diblemma samarensis*. I have never seen juvenile specimens showing any peculiarity in their fructification, but atavistic fronds, partly sterile and partly fertile, are not rare; see Plate 1, *a*. From them, and from the development of the fruiting area of young fronds, it seems proper to conclude positively that this

[1] When dealing with a large group, and a clearly related small but more-specialized group of more-restricted range, there is a presumption, in the absence of evidence, that the latter is descended from the former. This was my first judgment as to the relationship of *Leptochilus* and *Phymatodes*; but I have some evidence, which requires further study, suggesting that they may have a joint source, in or near *Christiopteris*.

fern is not descended from others with elongate sori oblique to the costa; that is, from any fern that could be called *Selliguea*. Aside from habitat, texture, and venation, the ancestry of *Leptochilus* is betrayed also by the presence of an apparent joint at the insertion of the stipe on the rhizome. As to this, Presl[5] says flatly: "Frondes heteromorphae, glaberrimae, cum rhizomate articulatae."

The plant owes its specific name to the accident that in the specimens in the hands of Cavanilles the fertile fronds seemed to be borne in the axils of the sterile. What happens is that branch buds are borne in these axils, sometimes almost as regularly as in any flowering plant (Plate 1, *b*). These buds may form ordinary branches; and, as the old parts of the rhizome live long, the common result is a complicated mass of stems, all still connected. The most of these buds, however, remain very short, but produce a succession of leaves, usually one at a time, functioning quite as do the dwarf branches of *Larix*. By the activity of the dwarf branches, old parts of the rhizome continue to produce leaves, so that a plant commonly bears a very large number at all times.

The type locality is given as Luzon, "in dry places." It is commonly found in places not at all dry; for example, it is very common in Laguna Province, Luzon, near the line between land in cultivation and the forest, a zone subject, because of its humidity, to the bud rot of the coco palm. The species is found west to India, and east at least to the extremity of Papua, and preserves a notable uniformity throughout this range. Specimens from Kaiser-Wilhelms Land and Papua are more caudate than is common farther west, and a specimen from Siam has the lamina decurrent to the rhizome.

LEPTOCHILUS PLATYPHYLLUS Copeland, sp. nov. Plate 2.

L. frondibus subsessilibus ca. 30 cm longis, ca. 8 cm latis, brevi-acuminatis, supra basin ad 1–2 cm et ad basin abrupte ad stipitem 2–3 mm longum contractis; fertilibus 20–25 cm longis, stipitibus 5 cm longis exceptis, usque ad 1 cm latis, marginibus in herbario revolutis; aliter L. axillari similis.

Sumatra, *Hancock 61*, 1862. Type in the United States National Herbarium, No. 1277348.

The broad and almost sessile fronds are too far from the range of ordinary variation of *L. axillaris* to justify treating this as a form of that species.

[5] Epim. 183.

Genus CAMPIUM Presl

Campium PRESL, Tentamen Pterid. (1836) 238, emended to include *Dendroglossa* PRESL, Epimeliae Bot. (1851) 149.

A genus of polypodiid ferns, descended from that group in § *Selliguea* called *Colysis* by Presl, as shown by the terrestrial habit, seriate fronds, and atavistic forms which intergrade with *Polypodium selliguea* Mettenius; rhizome creeping, usually short; articulation of stipe vestigial or none; frond simple and without main veins (*Dendroglossa*), or with pinnately arranged main veins or pinnate, or rarely bipinnate; veinlets anastomosing irregularly, or regularly along the costa and main veins; free included veinlets wanting or few and irregular, rarely somewhat regular; fertile fronds contracted, usually much so, the fructification typically acrostichoid.

For this genus the oldest distinctive name is *Campium* Presl, Tentamen Pterid. (1836) 238; Epim. Bot. (1849) 169. To Presl's disgust, J. Smith presently (1841 and 1842) set up a genus *Cyrtogonium*, and Fée (1845) a genus *Heteroneuron*, both for the same group. All of these genera were intended to include only normally pinnate ferns, with distinct main veins. Various of the species sometimes or usually bear simple fronds, but the main veins still have their evident character.

Another group of these ferns, usually of quite distinct appearance, has simple, small fronds, and no strong, straight main veins. To these, Presl [6] gave the distinctive generic name *Dendroglossa*. "Maxime affine est hoc genus Selligueae, differt praeter habitum peculiarem venarum costaeformium absentia . . . . A Colysi differt illico frondibus dimorphis." It is unfortunate that more students have not had Presl's eye for affinity. His *Colysis membranacea*, of late construed as *Polypodium selliguea* Mettenius, is in fact so nearly related to his *Dendroglossa* that it is sometimes difficult to decide which genus is represented by an atavistic specimen of *Dendroglossa linnaeana*.

As to the habitat, Presl says, in the generic diagnosis, "Rhizoma in cortice arborum putrescente repens;" which is incorrect and hard to understand. His first species is *Dendroglossa normalis* (*Gymnopteris normale* J. Smith; Cuming pl. Phil. No. 326). The label of my specimen bearing this number has no note respecting the habitat, nor have any of the Cuming labels I have seen; but I know the fern very well, and have never

[6] Epim. Bot. (1851) 149.

found it except on rocky creek banks. As to his other species, *Dendroglossa lanceolata*, Presl says: "Habitat in argillosis ad terram." The fact is that these ferns are typically terrestrial and have a terrestrial ancestry, so far independent of that of *Leptochilus*, with which, therefore, they cannot be congeneric. How far back into the so-called *Polypodium* it would be necessary to go to find a common parentage for both groups, I have not tried to ascertain; and the question is irrelevant, because nobody would seek to combine in one genus the species with distinct sori and their descendants with acrostichoid fruit.

Presl's supposed genera, *Campium* and *Dendroglossa*, usually seem distinct and easily recognizable; but not always. *Dendroglossa* has typically linear fertile fronds and sterile fronds without evident main veins; but its range of forms extends, not merely in one direction to the production of widened fertile fronds with unmistakably selligueoid sori, but also in another to the production of exceptionally large and broad sterile fronds with correspondingly well-developed main veins. Whether or not Hooker [7] is correct in treating as a close relative of this plant one with deeply laciniate-pinnatifid fronds; the moment that main veins are developed, the essential condition for pinnate dissection is provided. This is not the only place in the group where the same line is broken over. *Leptochilus hydrophyllus* is a typical *Dendroglossa* if judged by the most of the material collected; but one exceptional frond, the largest, shows a correlated tendency towards strengthening the main veins. The line between *Dendroglossa* and *Campium* seems to be crossed independently in at least two places—from *C. lanceolatum* toward *C. decurrens*, and between *C. hydrophyllum* and *C. subsimplex*—wherefore, it cannot properly be maintained as a line between genera.

If the genus *Campium*, as here construed, is monophyletic, its most primitive component seems to be the Philippine form of *C. linnaeanum*, and the outside parent is very closely represented by *Polypodium selliguea*. This matter of recognizable parenthood is emphasized by repetition, because, as our knowledge of relationships grows complete, this becomes the most essential element of generic character—the other general consideration in determining what groups should be genera being convenience.

While the genus *Campium* as a whole is, for the present, delim-

[7] Sp. Fil. 5: 277.

ited with reasonable clearness and is perfectly recognizable by anybody fairly acquainted with these ferns, the satisfactory definition of some of the species is quite impossible. The following list and keys are, therefore, to be taken as expressing such judgment in the matter as I have at present. From India to Papua, there are species that are characteristically unstable. As two of the most rich in forms, as construed of late, have Philippine types, and vary in the Philippines as freely as is easily imaginable, a wealth of Philippine material is particularly valuable in their interpretation.

Key to the species of the section Dendroglossa.

§ 1. Fronds simple, entire, and without main veins ... § 1. *Dendroglossa.*
- 1. Sterile fronds small, under 7.5 cm long.
  - 2. Fronds narrowed toward the base.
    - 3. Sessile or nearly so ... 2. *C. minus.*
    - 3. Long-stipitate ... 3. *C. minutulum.*
  - 2. Base truncate or subcordate ... 4. *C. dilatatum.*
- 1. Sterile fronds typically 10 cm or more long.
  - 2. Sterile fronds sessile or nearly so.
    - 3. Lanceolate ... 5. *C. metallicum.*
    - 3. Linear ... 6. *C. wallii.*
  - 2. Sterile fronds stipitate.
    - 3. Base narrowed abruptly ... 12. *C. hydrophyllum.*
    - 3. Tapering to the base.
      - 4. Stipe less than 6 cm long ... 1. *C. linnaeanum.*
      - 4. Stipe more than 10 cm long ... 7. *C. lanceolatum.*

§ 2. Fronds pinnate or main veins conspicuous . § 2. *Heteroneuron* (p. 349).

1. CAMPIUM LINNAEANUM (Fée) Copeland, comb. nov. Plate 3.

Leptochilus linnaeanus FÉE, Acrost. (1845) 87, pl. 47, fig. 2.

Frondibus sterilibus anguste lanceolatis, curvatis membranaceis, glabris, apice longe acuminatis, basi cuneatis, margine repando, petiolis squamosis; fertilibus longius petiolatis, linearibus utrinque acutis; rhizomate flexuoso, crasso, crassitie pennae columbae; sporangiis rotundatis, annulo 12 articulato, sporis ovoideis nudis.

Acrostichum lanceolatum, Linn. . . .

Habitat ad terram argilosam in Java (Zollinger).—V. S. in Herb. Jussieu et de Lessert.

Exsiccatum: Zollinger, no. 1441.

Dimensions: Frondes stériles, longueur, 16–18 centim., avec un pétiole de 5 centim. environ; largeur, 15 millim.—Frondes fertiles, longueur, 18–19 centim., avec un pétiole, qui a les deux tiers environ de cette dimension; largeur, 3 millim.—FÉE.

In further notes, Fée compares this with his *Leptochilus minor*, noting the paucity of free included veinlets in both, as compared, presumably, with his *L. lanceolatus*. Fée's citation

of Linnæus is most remarkable. Assuming it to be correct, why did he not transfer the Linnæan specific name, instead of, higher up on the same page, using that name for a different species? The clear fact is that the citation is not correct.

I believe the Mindanao fern, the subject of Plate 3, *b*, is correctly identified as this species, and that it is properly conspecific with the common Luzon fern shown on the same plate. Statements as to the range of this species, *Campium lanceolatum*, and *C. decurrens* may well be mistrusted.

As is the case with all of this group, the rhizome is slender, creeping on the ground or on rocks, commonly in moss, characteristically occurring on the banks of streams in mountain woods, at moderate altitudes. It is more or less persistently clothed, in the common Philippine fern, with narrowly lanceolate, long-acuminate scales, 2 to 3 millimeters long when intact.

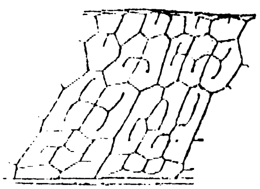


FIG. 1. *Campium linnaeanum* (Fée) Copeland, comb. nov.: Davao.

Typically, the sterile frond is a decimeter and upward in length, narrowed gradually and not very unequally toward both ends, six to ten times as long as broad, and borne on a stipe more or less 5 centimeters long, the lamina decurrent on the upper part of it. Fée's figures are good, but I include another because his are not generally accessible. The fertile frond is typically long-stalked, and hardly wider than filiform. The sterile frond is typically without straight main veins, but in exceptionally large or broad fronds there is always a tendency for the primary branches of the costa to straighten and become conspicuous. The veinlets anastomose freely, with few to many free included veinlets. Corresponding with the herbaceous texture, the areolæ are fairly large.

Another form, commoner in the Philippines (Plate 3, *a*), has the lamina decurrent almost, or rarely quite, to the rhizome, and its fertile frond tends to maintain some width of lamina. This fertile frond is rarely quite filiform, most commonly linear, rarely a centimeter or more in width; and these broader fronds always, at least when young, bear distinct, elongate, obliquely placed sori. Between such a form as this and Blume's *Grammitis membranacea*, *Polypodium selliguea* Mettenius, there might be an open gap; but it is occupied by *Polypodium fluviatile* Lauterbach, from the edge of a creek in Borneo. This and an unnamed Hainan plant differ from *P. selliguea* in being mod-

erately dimorphous. The transition from "*Polypodium*" to *Campium* is thus very completely bridged.

Gymnopteris dichotomophlebia Hayata, Icones Plantarum Formosanarum 4 (1914) 201, seems to be this commonest Philippine form with the fertile fronds very narrow. Hayata's description is very complete and accompanied by figures, and shows nothing distinctive except in the scale from the rhizome. As described and figured, this is imbricate-cordate and hardly acute. Such scales are known to me in the group only as they commonly and eventually lose their characteristic attenuate tips, with age and wear. This is described from Hainan, whence we have also the dimorphous *Polypodium* just mentioned. It is possible that Hayata's specific name should be applied to the Luzon plant.

2. **CAMPIUM MINUS** (Fée) Copeland, comb. nov. Plate 4, fig. 1.

Leptochilus minor FÉE, Acrostichum (1845) 87, pl. 25, fig. 3.

Frondibus sterilibus lanceolatis, basi attenuatis, apice obtusiusculis, longe petiolatis, glabris; fertilibus anguste linearibus obtusiusculis, longioribus; mesoneuro complanato; rhizomate repente; sporangiis brevissime pedunculatis, annulo 14 articulato, sporis ovalibus, laevibus.

Gymnopteris normale, J. Smith, Enum. fil., Cuming, in Journ. of Bot., Hook., mai, 1841.

Exsiccatum: Cuming no. 326.

Habitat in insulis Philippinarum (Cuming). V. S.

Dimensions: Longueur des frondules fertiles, 9 centim., sur un centim. de largeur; des frondules stériles, 15 centim.; sur un millim. de largeur. — FÉE. (The fronds are certainly reversed in this statement of size.)

This description of a little fern with long-stipitate sterile fronds does not fit the common Philippine form with the fronds sessile or nearly so. Neither does it apply well to the specimens of *Cuming 326* in Hooker's, or Presl's, or my herbarium. The scant material in the Gray Herbarium is intermediate.

It applies better to a plant of northern India,[8] which is the following species. For these reasons, I [9] revived the name first given the Philippine species by J. Smith, and used by Presl, *Leptochilus normalis* (J. Smith). However, it has since become evident that there can be found in the Philippines specimens which conform to Fée's description, and that these are merely stipitate examples of the normally sessile fronds. They are rare

[8] See Hooker, Sp. Fil. 5: 277 (the accompanying drawing of a frond is from the Hooker and Thomson collection cited there).

[9] Philip. Journ. Sci. § C 3 (1908) 31.

near Los Baños, Laguna Province, Luzon, where the sessile form is common; but *Elmer 16728*, from Sorsogon, which adjoins Samar, distributed with my imperfect determination as *Leptochilus normalis*, has mostly stipitate fronds. Under the circumstances, I am forced to the conclusion that *Cuming 326* is all the same species, and that it must bear Fée's specific name, as the first to be accompanied by a diagnosis.

The little plants of Khasia and the Philippines are really not identical. The difference is not essentially in venation, as might appear from my drawings. The Philippine specimen drawn represents the extreme of absence of free included veinlets and of

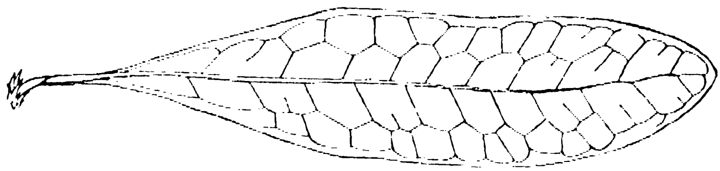


FIG. 2. *Campium minus* (Fée) Copeland, comb. nov.; a normal leaf from Los Baños, Laguna. Free included veinlets are usually much more numerous.

fine submarginal network, and I have Philippine fronds which in these respects are essentially like the Khasia specimen drawn; but the Philippine specimens are consistently shorter-stipitate, with relatively narrower and less-decurrent lamina. What is more significant, they have blacker, narrower, and more-toothed paleæ. The importance of this lies in the fact that in paleæ, as well as in frond form and stipes, the minute ferns of each region betray their affinity to the larger ferns of the same region, instead of to one another. Therefore, it requires no unreasonably fine discrimination to recognize these as specifically distinct, similar as they are in appearance.

3. **CAMPIUM MINUTULUM** (Fée) Copeland, comb. nov.

Leptochilus minutulus FÉE, Mém. 10 (1865) 8, pl. 31, fig. 2.

Les frondes stériles sont oblongues, obtuses, assez longuement pétiolées, a marge des lames sinuées; la lame fertile est presque lancéolée; les frondes sont portées sur un rhizome délié. Les frondes stériles ressemblent aux frondes stériles des *Craspedaria;* nous en donnons la figure, tab. XXXI, fig. 2, sous le nom de *L. minutulus*. —FÉE.

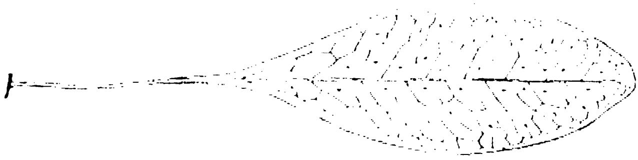


FIG. 3. *Campium minutulum* (Fée) Copeland, comb. nov.; Khasia, *Hooker and Thomson*.

This description is of a Khasia fern collected by Hooker and Thomson, and is to distinguish it from the Philippine *Leptochilus minor*. For a further comparison of the two, see the remarks under the preceding species. Gustav Mann has collected the same fern in about the same place, United States National Herbarium No. 329564.

4. CAMPIUM DILATATUM Copeland, sp. nov. Plate 4, fig. 2.

Rhizomate repente, 1–2 mm crasso, paleis minutis fuscis acuminatis vestito; stipitibus remotis, gracilibus, fr. sterilium 2–4 cm, fertilium fere 20 cm altis, nudis; fronde sterile herbacea, glabra, rotundato-oblonga, usque ad 4 cm longa et 3 cm lata, apice rotundata, basi truncata vel subcordata, margine integra vel undulata, costa infra apicem dissipata, venis primariis nullis, venulis irregulariter anastomantibus cum liberis inclusis; fronde fertile ca. 5 cm longa, anguste lineare.

Hainan, Kap Kao, altitude 100 meters, on rocks over river, *Eryl Smith 1446*, 1923. Type in the herbarium of the University of California, No. 234119.

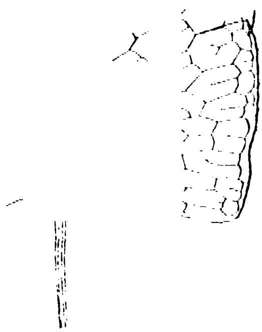


Fig. 4. *Campium dilatatum* Copeland, sp. nov.; type.

Among the recognized members of the *Dendroglossa* group, this is sharply marked off by the broad sterile frond. *Polypodium cantoniense* Baker, as figured by Hooker,[10] suggests it strongly, but seems to differ essentially in the broader fertile frond, as well as in being coarser throughout. It is very probable that this is where it belongs. If so, Christ was far astray in transferring it to *Christiopteris*. Baker is silent as to its texture, which is a critical character; but *Christiopteris* has also very characteristic paleæ, not at all like those of this fern.

5. CAMPIUM METALLICUM (Beddome) Copeland, comb. nov.

Gymnopteris metallica Beddome, Ferns Brit. India, Suppl. (1876) 26, pl. 390.

Fronds quite sessile 3–7 inches long up to nearly 1 inch broad of a deep shining metallic blue color, fertile fronds only soriferous towards the apex. Ceylon in dense moist forests on the Haycock mountain growing on rocks. This is intermediate between Wallii and true lanceolata and is, I believe, only a variety of the latter, it is a very beautiful plant. Beddome.

[10] Ic. Pl. pl. 1685.

Beddome[11] adds that the main veins are often indistinguishable from the others, and omits his doubt as to the specific status. As he conceived his *Gymnopteris lanceolata*, or *G. variabilis*, as broad enough to include *Campium decurrens* and *Leptochilus axillaris*, the inclusion of other real species of *Dendroglossa* would not be surprising.

The sterile frond is rigidly chartaceous and remarkably opaque. The larger ones have, as Beddome's plate shows, a stipe, not more than 5 millimeters long. In the one specimen in the Gray Herbarium, the fertile frond has a filiform stipe about 15 centimeters long. The fertile "lamina" is itself less than 1 millimeter wide, and 12 centimeters long with a broken apex; it consists of a sterile costa, and just enough lamina to anchor the sporangia. The young rhizome bears dark, shining, clathrate, lanceolate-acuminate paleæ, with very minutely spiny margins. Under the microscope, the walls are chestnut and the contents colorless. The rhizome is 1.5 millimeters in diameter, bearing fronds about 1 centimeter apart.

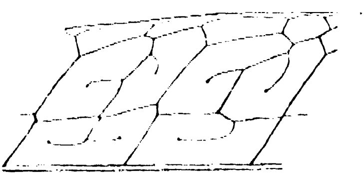


FIG. 5. *Campium metallicum* (Beddome) Copeland, comb. nov.

6. CAMPIUM WALLII (Baker) Copeland, comb. nov.

Acrostichum (*Chrysodium*) *wallii* BAKER, Journ. Bot. 10 (1872) 146.

Rhizomate gracili reptante paleis lanceolatis subsecundis vestito, frondibus segregatis sterilibus subsessilibus anguste ligulatis glabris membranaceis viridibus nullo modo squamosis obtusis margine obscure late repandulis basi cuneatis, maculis inter costam et marginem uniseriatis valde verticaliter elongatis vena unica centrali decurvata saepissime praeditis, frondibus fertilibus gracillimis filiformibus longe petiolatis.—BAKER.

Ceylon.

The sterile fronds are 20 to 25 centimeters long and 4 to 6 millimeters wide; fertile frond, 15 to 20 centimeters long, its stipe 8 to 15 centimeters. The narrow sterile frond, and consequent single row of areolæ on each side of the costa, distinguish this from *Campium linnaeanum*.

7. CAMPIUM LANCEOLATUM (Fée) Copeland, comb. nov. Plate 5, fig. 2.

Leptochilus lanceolatus FÉE, Acrost. (1845) 87, pl. 47.

Frondibus simplicibus, glabris; sterilibus lanceolatis utrinque acutis, basi decurrentibus, membranaceis, margine repandis, subundulatis; fertilibus longissimis, linearibus, attenuatis, longe petiolatis, petiolis helveolis,

[11] Ferns Brit. India and Ceylon (1892).

laevibus; rhizomate repente, fibrillis tomentosis, fusco-rufis; sporangiis late ovatis, annulo 14 articulato; sporis ovoideis, laevibus nudis.

Habitat in Indostan, Neilgherries (Perottet, 1838).—V. S. in herb. de Lessert.

Exsiccatum: Hügel, Asia, no. 1348, in herb. Vindob.

Dimensions: Frondes stériles, longueur, 60-65 centim.; le petiole égale la lame en dimension; largeur, 5 6 centim.

Frondes fertiles, longueur, 75 centim., le pétiole ayant 50 centim., largeur, 3-4 millim.—FÉE.

I have not seen a specimen positively referable to this species except from peninsular India, where it seems to be common. Specimens with this name, from Sikkim, Assam, etc., approach *Campium decurrens*, which also occurs there. Beddome ascribes to this species (as a variety of *Gymnopteris variabilis*) a wide range of forms, differing in shape, and particularly in the fructification, variously restricted, and even broken into distinct sori. I do not try to decide from the descriptions what these forms may be. So far as I can judge from the specimens examined, this species has been construed correctly as including *Leptochilus thwaitesianus* Fée.

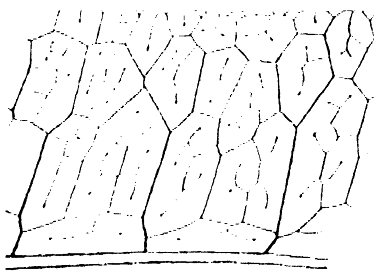


FIG. 6. *Campium lanceolatum* (Fée) Copeland, comb. nov.; peninsular India.

Key to the Oriental species of the section Heteroneuron.

Fronds pinnate or main veins conspicuous.................... § 2. *Heteroneuron*.
(For key to the African species, see p. 393.)

1. Sterile fronds simple and undivided.
  2. Free included veinlets many.
    3. Fertile frond narrowly linear.
      4. Stipe not articulate .... 8. *C. decurrens*.
      4. Stipe jointed to rhizome.................... 10. *C. laciniatum*.
    3. Fertile frond lanceolate .... 11*a*. *A. zollingeri*.
    3. Fertile frond broad and short .... 9. *C. ovatum*.
  2. Free included veinlets few or none.
    3. Fertile frond linear .... 17. *C. foxworthyi*.
    3. Fertile frond broader.
      4. Frond thick and dark .... 11. *C. subsimplex*.
      4. Frond thin, light green .... 15. *C. diversifolium*.
1. Fronds regularly pinnatifid with many near-pinnæ.
  2. Free included veins few or none .... 27. *C. neglectum*.
  2. Free included veinlets in all areolæ.................... 10. *C. laciniatum*.
1. Fronds trifid or paucipinnate, or dwarfed.
  2. Stipe stout, frond thick and dark.................... 11. *C. subsimplex*.
  2. Frond not thick and dark.
    3. Fronds usually less than 15 cm tall.

4. Apex made up of coadunate pinnæ.
5. Areolæ of pinnæ all costal.
6. Pinnæ approximate .... 28. *C. taylori.*
6. Frond lax .... 30. *C. argutum.*
5. Areolæ more numerous .... 29. *C. parvum.*
4. Apex not formed of fused pinnæ.
5. Terminal leaflet narrowly linear .... 18. *C. tenuissimum.*
5. Apex not lashlike .... 19. *C. cuspidatum.*
3. Fronds of moderate size or large.
4. Not proliferous.
5. Pinnæ at most two pairs .... 15. *C. diversifolium.*
5. Pinnæ about four pairs .... 16. *C. pseudoscalpturatum.*
6. Apical segment crenate-lobed .... 32. *C. boivini.*
6. Apical leaflet serrulate .... 42. *C. bradfordi.*
4. Normally proliferous.
5. Pinnæ coadunate above the base .... 26. *C. rivulare.*
5. Apex normally one leaflet.
6. Paleæ on stipe few, not dark .... 13. *C. heteroclitum.*
6. Stipe clothed with dark scales .... 14. *C. nigrum.*
1. Not dwarfs, pinnæ several, dark and coriaceous .... 11. *C. subsimplex.*
11*b*. *G. cadieri.*
1. Not dwarfs, pinnæ numerous, not dark and thick.
2. Apex made up of coadunate pinnæ.
3. Pinnæ crenate to shallowly lobed.
4. Pinnæ cuneate on both sides.
5. Lobes toothed or crenate .... 24. *C. palustre.*
5. Lobes entire .... 25. *C. samoensis.*
4. Base of pinna broad.
5. Free pinnæ merging into lobes.
6. Pinnæ lanceolate, acute .... 21. *C. validum.*
6. Pinnæ broader, acuminate .... 20. *C. quoyanum.*
5. Change from pinnæ to lobes abrupt.
6. Pinnæ broadest below middle .... 22. *C. subcordatum.*
6. Pinnæ broadest above middle .... 23. *C. interlineatum.*
3. Pinnæ cut over half-way to costa.
4. Areolæ all costal .... 28. *C. taylori.*
4. Areolæ along costa and main veins .... 30. *C. argutum.*
4. Areolæ not all touching main veins.
5. Areolæ between sinus and costa not very broad.
20. *C. quoyanum.*
5. Areolæ between sinus and costa very broad.
31. *C. bipinnatifidum.*
3. Pinnæ hardly crenate .... 33. *C. semicordatum.*
3. Pinnæ quite entire .... 32. *C. boivini.*
2. Apical leaflet not made by fusion.
3. Veinlets uniting in pairs, with an excurrent one where they meet, as in *Goniopteris.*
4. Pinnæ narrowly lanceolate .... 45. *C. féeanum.*
4. Pinnæ broad.
5. Green, apex proliferous .... 44. *C. subcrenatum.*
5. Brownish, apex not proliferous .... 43. *C. molle.*

3. Venation more ample.
   4. Veins or entire frond reddish.
      5. Coriaceous and entire .... 39. *C. costatum.*
      5. Herbaceous and toothed .... 37. *C. scalpturatum.*
   4. Green, usually light.
      5. Veinlets all free near margin.
         6. Margin crisped, not crenate .... 36. *C. crispatulum.*
         6. Margin crenate, not crisped.
            7. Sporangia remote from costa .... 38. *C. undulatum.*
            7. Sporangia covering the surface .... 35. *C. angustipinnum.*
      5. Veinlets uniting to near margin.
         6. Pinnæ over 20 cm long, narrow .... 34. *C. lanceum.*
         6. Pinnæ 10 to 20 cm long, broad.
            7. Fertile fronds broad .... 40. *C. deltigerum.*
            7. Fertile fronds linear .... 41. *C. virens.*
         6. Pinnæ hardly 10 cm long .... 33. *C. semicordatum.*

8. CAMPIUM DECURRENS (Blume) Copeland, comb. nov.

Leptochilus decurrens BLUME, Enum. Pl. Jav. (1828) 206.

L. frondibus simplicibus membranaceis glabris longe stipitatis, sterili cuneato-oblonga basi in stipitem decurrenti parallelo-venosa reticulata, fertili angusto-lineari elongata.

Obs. Priori (L. axillari) differt fronde sterili lato-oblonga, fertili longissima.

Crescit in humidis montanis Javae.—BLUME.

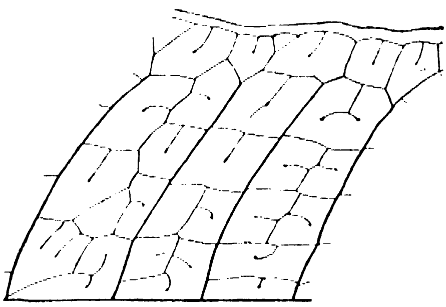


FIG. 7. *Campium decurrens* (Blume) Copeland, comb. nov.; Java, *Winckel 1335B.*

Sterile fronds 20 centimeters (or considerably more) long, including the stout stipe, along a part or all of which the lamina is decurrent; apex usually acuminate to caudate; color rather dark above, and brownish beneath; texture firm but not thick; main veins somewhat oblique in Malaya, almost horizontal in India, conspicuous nearly to the margin. An Assam specimen in the United States National Herbarium, collected by Gustav Mann, has a frond 65 centimeters long without the tip, and 12 centimeters wide.

The accepted range is Malaya to India.

In Malaya this is a decidedly uniform fern, for its genus. *Acrostichum variabile* Hooker, Sp. Fil. 5 (1864) 277, is a pure synonym, evidently provided because Blume's specific name was preoccupied in *Acrostichum.* The Himalayan ferns, on which Hooker's diagnosis was primarily based, seem to differ constantly from those in Malaya in having the main veins at very nearly a right angle to the costa, and more remote from one another, but this would ill justify specific separation. The status of Hooker's var. *β laciniatum*, of southern India and Ceylon, is decidedly different (see No. 13, *C. laciniatum*). Beddome[12] puts it under his var. *lanceolata*, where a laciniate or pinnate frond is even less to be looked for; but Beddome's usual skill in the recognition of species deserted him completely in this group, to which he also reduced, as a mere variety, as distinct a fern as *Leptochilus axillaris.* Because of his confusion, I abstain from trying to draw conclusions from his report of a form, apparently Burmese, with broad fertile fronds and polypodioid sori. In consideration of the existence of such forms, if indeed they are of this species, and of the very characteristic venation, it will not surprise me if future study shows that *Campium decurrens* originated in *Phymatodes*, or *Selliguea*, independently of *Leptochilus* and of the *Dendroglossa* group, and therefore requires generic separation. A vestigial articulation of the stipe is often evident, and on some young specimens it is clearly functional.

8a. **CAMPIUM ZEYLANICUM** (Fée) Copeland, comb. nov.

Leptochilus zeylanicus FÉE, 10th Mém. (1865) 8, pl. 31, fig. 1.

Frondibus sterilibus late lanceolatis, sessilibus, laminis decurrentibus, acutis; nervatione campyloneurorum, sed magis irregulari; fertilibus angustisimis, longissimis, petiolo nudo, extenso; sporangiis ovoideis, annulo lato 16–18 articulato; sporis brevibus, reniformibus.

Habitat in insula Zeylanica, (Thwaites, no. 1317.)

Filix repens, rhizomate tenui.

Cette espèce a quelque chose du porte du *L. decurrens*, mais elle en diffère essentiellement par la nature du tissu des frondes stériles, par les dimensions et par la manière dont est constitué le réseau nervillaire, a mailles extrêmement petites; c'est aussi là ce qui la sépare du *L. hilocarpus*, espèce à frondes plus courtes et plus manifestement sessiles.—FÉE.

Fée distinguishes this from *C. decurrens* by the texture, which he does not describe; by venation, as to which his figure and notes do not agree; and size, his figure showing a frond about 20 centimeters by 4—rather small, but well within the range of

[12] Ferns of British India and Ceylon 430.

C. decurrens. It is not strange that later authors combined the two. A plant in the United States National Herbarium, No. 815200, ex herbarium William Ferguson, seems to be altogether typical of this species, although one frond is 30 centimeters tall. The areolæ are not at all small, nor does Fée's figure so show them, but the venation is still distinct, in that the veins parallel to the costa, normally conspicuous in *C. decurrens*, are not developed in *C. zeylanicum*. The frond is more coriaceous, and very opaque, having to be cleared before strong transmitted light will reveal the venation. There is at least a vestigial articulation of stipe to rhizome. There is no such contraction of the frond some distance above the base, as is characteristic of *C. decurrens* in the Malay region. The paleæ are finely and regularly toothed.

FIG. 8. *Campium zeylanicum* (Fée) Copeland, comb. nov.

The Ceylon fern discussed on page 355, as a possible simple form of *C. laciniatum*, is longer-stalked, narrower, lighter in color, thinner, and with evident venation.

ACROSTICUM LISTERI Baker.

Acrostichum (§ *Gymnopteris*) *listeri* BAKER, Journ. Linn. Soc. Bot. 25 (1890) 361.

A. rhizomate late repente crassitie cygni pennæ, stipitibus sterilibus elongatis subnudis haud contiguis, frondibus lanceolatis membranaceis acutis basi attenuatis, venis primariis perspicuis parallelis, intermediis in areolas copiosas hexagonas anastomosantes venulis liberis inclusis productis, frondibus fertilibus linearibus stipitibus longioribus.

A well-marked new species, allied to the Himalayan, Ceylonese, and Malayan *A. variabile*, Hook. Stipes of the sterile frond 7–8 inches long. Sterile frond 9–12 in. long, 2 in. broad, narrowed gradually to the apex and more suddenly to the base. Fertile frond 4–5 in. long, under ½ in. broad at the middle, narrowed gradually to both ends.—BAKER.

Christmas Island (200 miles south of Java).

This is evidently large and long-stalked, and the implication is that the fertile frond is notably broad; otherwise, this seems to be closer to the *Campium decurrens* of Java than are many of the Indian forms which Baker treated as that species (under the name of *Acrostichum variabile*). I have seen no specimen.

9. CAMPIUM OVATUM Copeland, comb. nov. Plate 6.

Leptochilus ovatus COPELAND, Philip. Journ. Sci. § C 9 (1914) 229.

Fronde sterile lata, venarum ramis prope marginem praestantioribus; frondis fertilis stipite 35 cm alto, gracile, lamina anguste ovata, vix 6 cm longa, 2.5 cm lata; aliter L. decurrenti Bl. similis.

No. 155. "Scandent near base of small trees, in moist shade."—COPELAND.

The type specimen was collected by Cecil J. Brooks at Lebong Tandai, Benkoelen, Sumatra. There is an obvious possibility,

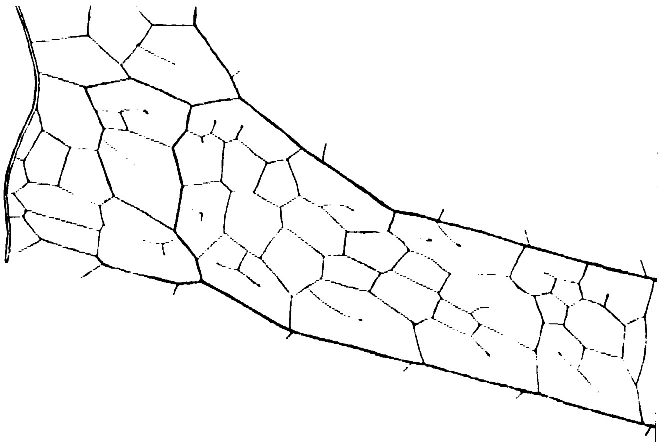


FIG. 9. *Campium ovatum* Copeland, comb. nov.; type. Frond simple.

emphasized by Mr. Brooks's note on the habit, that this is an independent offshoot of *Selliguea;* but I think it more likely that it is a real relative of the ferns with which it stands here.

10. CAMPIUM LACINIATUM Copeland, sp. nov. Plate 7.

Rhizomate repente, 2–3 mm crasso, nigro prope apicem paleis nigro-fuscis ca. 2 mm longis ovatis acutis suberoso-denticulatis basibus aut peltatis aut profunde cordatis cum lobis basalibus imbricatis vestito, alibi sparse paleato vel glabrescente; stipitibus seriatis, articulatis, gracilibus, stramineis vel fulvis, frondium sterilium 5–20 cm, fertilium 12–25 cm altis; fronde sterile deltoideo-ovata, 15–25 cm alta, 15–25 cm lata, acuta vel

acuminata, basi anguste et abrupte decurrente, glabra, membranacea, pinnatim laciniata, ala costae 1–10 mm lata, laciniis plerumque lanceolatis, remotis, late patentibus, acutis vel acuminatis, integris vel rarius frondium majorum infimis iterum laciniatis, venatione secundum dissectionem frondis irregulare, costulis rectis, venis ubi latior lamina subrectis, venulis ubique anastomosantibus cum liberis saepius furcatis apicibus globosis in areolis omnibus; fronde fertile 15–25 cm alta, deorsum pinnata, sursum ad alam angustissimam rhacheos fructiferam pinnatifida, ramis remotis, 3–6 utroque latere, usque ad 10 cm longis, 1 mm latis, infimis saepe furcatis.

Ceylon. Type in the Gray Herbarium, ex herbario William Ferguson. In same herbarium, *Thwaites* and *Beckett 215;* in the United States National Herbarium, No. 1277199, *Hancock 44*.

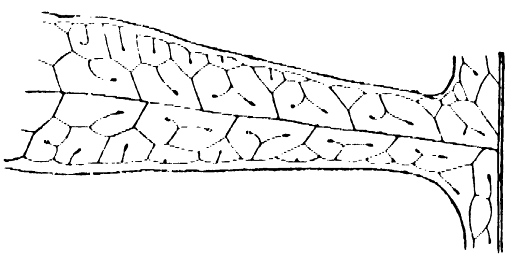


FIG. 10. *Campium laciniatum* Copeland, sp. nov.: type.

This is *Acrostichum decurrens* forma *fronde pinnatifida* Thwaites, Enum. Ceylon Plants, 381; *A. variabile* var. *laciniatum* Hooker, Spec. Fil. 5: 277. The affinity is to *Campium decurrens*, rather than to *C. lanceolatum*, as Beddome seemed to think.

However, the fern with entire fronds with which it may perhaps blend is not *Campium decurrens*, of which I have seen no Ceylon specimen. This fern, the subject of Plate 5, fig. 1, is represented in the Gray Herbarium by a specimen distributed from Kew as "*Acrost. lanceolatum* Hook. Peninsula Indiae Orientalis No. 3177. Herb. Wight." Contrasted with *Campium decurrens* the frond narrows uniformly from the widest part of the wing of the stipe, the veins are inconspicuous, the stipe is conspicuously jointed to the rhizome, and the paleæ are short and blackish. It is still less like *C. lanceolatum*. I leave it unnamed on the chance that it is a simple *C. laciniatum*, which I doubt its being. My more serious doubt is as to its being a true *Campium*.

11. CAMPIUM SUBSIMPLEX (Fée) Copeland, comb. nov. Plate 8.

Gymnopteris subsimplex FÉE, Acrost. (1845) 83, pl. 40, fig. 3.

Frondibus subsimplicibus, inaequaliter crenatis, glabris; sterilibus lanceolatis, basi subrepandis, nervillis secundariis flexuosis, nigrescentibus; fertilibus angustioribus acutis; sporangiis ovalibus, annulo 16 articulato, sporis episporio membranaceo,—siccitate lurida.

Habitat in Philippinis . . . Cuming no. 225.—FÉE.

Poecilopteris subrepanda Presl, Epim. Bot. (1851) 171, is absolutely synonymous with this, based on the same collection, and with similar description; Presl simply elected his specific name with the feeling, general in his time, that such publication as Smith's list of names of Cuming's plants should be accepted as establishing these names.

This is a common fern in the Philippines. It probably has a very much wider range, but this is uncertain because of confusion of names. *Dr. King's collector 8398*, from Perak, is this species. It is the most variable species in the genus. Its general distinctive characters are the stout, woody rhizome with large paleæ, stout stipes, and thick fronds, dark green above and olive green beneath, with strictly toothless margin, and the fertile frond or pinnæ never narrowly linear. The rhizome is 4 to 10 millimeters thick, and the brown or blackish scales up to 1 centimeter long on large specimens. The stipes are almost clustered, stout, dark, usually glabrescent, those of the sterile plant from quite short up to 30 centimeters long, winged upward if the frond is simple, those of the fertile fronds of the same plants the longer.

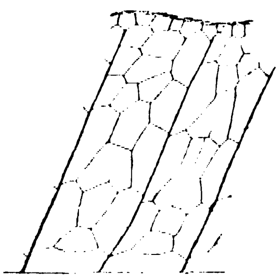


FIG. 11. *Campium subsimplex* (Fée) Copeland, comb. nov.; *Bolster 244.*

The sterile fronds are: 1, simple and sometimes very large, even up to 50 centimeters long and 9 centimeters wide, short-acuminate and long-decurrent, entire or slightly sinuate; 2, pinnate with very few pinnæ, and the upper part like a simple frond; or 3, pinnate with half a dozen pairs of pinnæ and the apical leaflet like the others. The last form is the rarest, but can be construed as representing the species in its fullest development. The type, as described, had a simple sterile frond. The simple and the paucipinnate forms are connected by fronds forked near the base on one or both sides. A rare transition form has several lobelike adnate decurrent pinnæ below the

large, simple body of the frond; another has one or two dwarfed pinnæ between a pair of large basal ones and the still larger apical leaflet. The fertile fronds or pinnæ are smaller, but never very narrow. The costa is prominent, and the main veins are likely to be sufficiently developed to break the mass of sporangia into groups.

A bud near the apex is not as constant a feature as it is in *Campium heteroclitum* and *C. quoyanum*, but is still common. It is more likely than in other species, while still connected with the parent plant, to grow into a daughter plant of considerable size, as shown in Plate 8. Bearing such daughter plants, it is quite surely *Leptochilus stolonifer* Christ.

The venation varies with the size and the dissection of the frond, but always retains the essential character of its group, betraying a certain affinity to *Campium heteroclitum*, the species that may be regarded as providing the pattern. If the lamina, of frond or pinna, is very ample, the veins are usually far apart, and two four rows of irregular areolæ may separate the regular ones bordering the main veins. If the pinnæ are narrower and the veins closer together, only one such row may be found. A few free included veinlets can usually be detected, but not many nor with any regularity; they are simply veinlets that would normally reach a connection with others, but fail to do so.

Probably identical with this is the following:

11a. ACROSTICHUM ZOLLINGERI Kunze.

Acrostichum zollingeri KUNZE, Bot. Zeit. 4 (1846) 419.

Fronde membranacea, glabra, lanceolata, apice attenuata, basi decurrente, margine repandula, costa subtus convexa, lurida venis primariis patentibus, prominulis, secundariis reticulatis, immersis, fronde sterili late lanceolata, in stipitem brevissimum longe decurrente; fertili anguste lanceolata basi attenuata, in stipitem mediocrem brevius decurrente; soris nec costam nec venas primarias obtengentibus, utriusque stipite fusco-paleacea, basi adscendente; rhizomate horizontali (brevi?) fusco-paleaceo, nigro-radicoso.

Frons sterilis illi *Leptochili decurrentis* Bl. (Fée Acrost. t. 48, f. 2) similis; sed fertilis diversissima, sterili subconformis, quamquam angustior. Frons circiter pedalis, lamina sterilis 9–10″ longa, 1″ 10‴ lata; fertilis 6½—7″ lango, 8‴ lata—KUNZE.

Java, *Zollinger 1293*.

The statement of van Alderwerelt,[13] who does not appear to have seen this fern, that it has copious free veinlets, may have

[13] Malayan Ferns 743.

been due to confusion with *Hemionitis zollingeri* Kurz, which is a *Hemigramma*, but also in its time endowed with a name in *Leptochilus*.

11b. GYMNOPTERIS (LEPTOCHILUS) CADIERI Christ.

Gymnopteris (*Leptochilus*) *cadieri* CHRIST, Journ. de Bot. **19** (1905) 126.

Voisin de *G. subrepanda* J. Sm. Bot. Journ. 3 403, mais plus mince, tissu et nervation différents.

Rhizomate repente crasso, cum basi stipitum squamis atro-brunneis subulatis rigidis vestito, foliis subfasciculatis, sipite 25 cent. longo lucido-rufo sulcato pennae corvinae crassitie, fronde deltoidea 30 cent. longa 25 cent. lata, pinnata, pinna terminali pinnisque utroque latere recheos tribus similibus fere sessilibus nec adnatis, confertis, 16 cent. longis 4 cent. latis basi ovato-rotundatis oblongis acuminatis, apice interdum producto gemmulamque minimam ferente, faciebus glabris, margine integro sed undulato-repandulo, textura coriacea, colore atrovirente, costa tenui manifesta, nervis tenuibus patentibus rectis usque ad marginem protensis 6 mill. distantibus, nervulis 5 inter costam et marginem, convexo-arcuatis, areolam duosque nervulos liberos clavatos areolam coronantes includentibus.

Lamina fertili 15 cent. longa longius stipitata, stipite 40 cent. longo 11 pinnis alternis remotis oblongis 5 cent. longis 2/3 cent. latis obtusis omnino sporangiis brunneis tectis.

Hab. (Annam) Thanh Than . . ., grandes forêts, bords des torrents. Fevr. 1905. Cadière *no.* 146.—CHRIST.

I do not know this fern, and insert it at this point entirely on the strength of Christ's statement as to its affinity; however, it must be noted that the presence of clavate free included veinlets throws doubt on this statement. Such veinlets are a characteristic of *Hemigramma* and are not found in any sure species of *Campium* with compound fronds.

12. CAMPIUM HYDROPHYLLUM (Copeland) Copeland, comb. nov. Plate 9.

Leptochilus hydrophyllus COPELAND, Philip. Journ. Sci. 1 Suppl. (1906) 146.

Rhizomate brevi-repente, 1-1.5 mm. crasso, apicem versus paleis fuscis, angustis, 1 mm. longis vestito; stipite frondis sterilis circa 1 cm. alto, subsquamoso, frondis fertilis 4-7 cm. alto; fronde sterile plerumque 10 cm. alta, 10 mm. lata, integra, rarius 20 cm. alta et undulata, acuta, basi subacuta, viva carnosula, sicca papyracea, glaberrima; venis immersis, inconspicuis, marginem vix attingentibus, venulis more *L. cuspidati* anastomosantibus, liberis inclusis paucis; fronde fertile lineare, ca. 7 cm. alta, 3 mm. lata, obtusa, in stipitem sensim angustata.

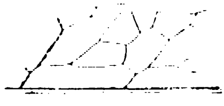


FIG. 12. *Campium hydrophyllum* Copeland, comb. nov.; type. Frond simple.

MINDANAO, Zamboanga, San Ramon, *Copeland* 1565. Ad saxa humida.—COPELAND.

The color is dark olivaceous-green. The color, texture, venation, and margin mark this as a near relative of *Campium subsimplex*, and I believe it is more reasonable to regard it as evolved by arrested development from that species than as a link between *C. subsimplex* and the *Dendroglossa* group, to no species of which it shows an equally clear affinity. In common with *C. subsimplex*, and various *Dendroglossa* species, it has dark, opaque fronds. Free included veinlets are not rare in broader fronds than the one drawn.

13. CAMPIUM HETEROCLITUM (Presl) Copeland, comb. nov.

Acrostichum heteroclitum PRESL, Rel. Haenk. 1 (1825) 15, pl. 2, fig. 2.

A. frondibus ternatis, foliolis lateralibus oblongo-lanceolatis acuminatis dentatis oppositis, intermedio lanceolato linearive, grosse dentato vel integerrimo, acuminato, fructiferae foliolis lineari-lanceolatis.—PRESL.

Presl followed his formal diagnosis with a list of five various forms, differing in the number of leaflets and in the elongation of the apex and production of bulbils or young plants. His illustration shows the commonest form, with one pair of lateral pinnæ, and the terminal leaflet long-attenuate and rooting.

Acrostichum flagelliferum Wallich: Hooker and Greville, Ic. Fil. (1829) pl. 23.

Fronde pinnata, pinnis paucis remotis lanceolatis (magisve minusve latis) breviter petiolatis, terminali longissima flagelliformi.

Hab. In India Orientali. *Rheede. Wallich.*—HOOKER AND GREVILLE.

A very variable fern. It is common at low altitudes, usually found in abundance, and a considerable range of forms can usually be collected, in the Philippines, wherever it is found. Simple fronds on adult plants are not uncommon; they are cuneate, broad above the base, with the upper part drawn out into the characteristic tail. Fronds cleft on one or both sides show the transition to the typical form. There may be more than one pair of pinnæ, but never many. These are stalked (except on transition forms from simple fronds), narrowed to the base, ovate, entire or undulate or obscurely and irregularly toothed, and acuminate or caudate; but proliferous pinnæ are very unusual. The terminal pinna may be broad near its base, like a simple frond; or it may be narrow throughout its length. It is not rare for its whiplashlike upper part, growing on and on until it touches the ground, to reach a length of well over half a meter.

The most characteristic feature of the species is this lash, which gave it the name by which it was long known, *Acrostichum flagelliferum*. The rhizome is wide-creeping, slender, consider-

ing the size of the fronds—3 to 4 millimeters in diameter, in adult plants—not very densely clothed with small, dark, scurfy scales. The stipes are seriate, not clustered at all, 15 to 30 centimeters long on sterile fronds, those of fertile fronds of the same plant somewhat longer, stramineous, sparsely scaly. The sterile fronds are thin, clearly green, neither blackish nor olive, paler on the nether side. The costa and conspicuous main veins are very pale. The fertile pinnæ are of the same general form as the sterile, but smaller and somewhat narrower, never narrowly linear.

An unusual variant, found, however, well throughout the range of the species, has the terminal leaflet like the lateral ones in shape, but usually larger. This form is *Cyrtogonium acuminatum* Brackenridge. Compensating for the comparative suppresion of terminal proliferation, the lateral pinnæ are likely to be notably caudate, with buds which are usually dormant.

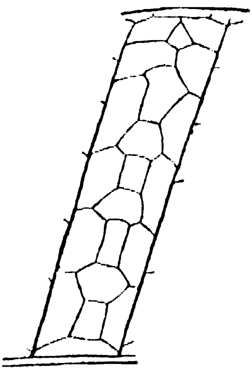


FIG. 13. *Campium heteroclitum* (Presl) Copeland, comb. nov.; *Cuming 6*.

The venation is ill figured by Presl in the Reliquiae Haenkeanae, and not too well in the Tentamen. Beside the single regular row of areolæ along each side of the costa, there is a less regular one on each side of each main vein. Typically, the middle of the space between each pair of veins is occupied by one more row of areolæ, twice as numerous. It is in this middle row that irregularity occurs, the commonest deviation being the presence of two or more irregular rows. Free included veinlets are wanting, except as an occasional veinlet fails to reach the one toward which it starts.

Range: Malaya to India, China, and Papua. From the Philippines to the Himalayas, there is a gradual loss of regularity in the venation.

Dealing with a group of plants like this, which, within limits, is exceedingly unstable, it is easy for the student to be baffled, and to conclude that the variation has no clear limits. In his treatment of this species, Christ[14] seems to me to have done this. Leaving out of account his *linnaeanus*, for the reduction of which a wrong determination must have been responsible, I

[14] Philip. Journ. Sci. § C 2 (1907) 159.

believe that two of the other three varieties he describes are established, if local, species. The transition to these, as I see it, is no more clear, and no more filled by known intermediate forms, than is that to *Campium diversifolium* or to several other species. Certainly, all are related.

CAMPIUM HETEROCLITUM var. EURYBASIS (Christ) Copeland, comb. nov.

Leptochilus heteroclitus var. *eurybasis* CHRIST, Philip. Journ. Sci. § C 2 (1907) 159.

This variety is based on *M. S. Clemens 552*, from Camp Keithley, Mindanao. Its characteristics are smaller stature and deeply cut lateral pinnæ which are short and very wide at the base, with toothed margins. As described, it looks like a distinct species, almost as near to *Campium quoyanum* as to *C. heteroclitum*. Very ample material, collected by Mrs. Clemens, partly bearing the stated number and partly without number, shows that it intergrades almost completely with the species to which Christ assigned it. Many fronds have the terminal leaflet drawn out, and a few have started to develop buds; and a few have the venation almost as regular as is here pictured for *C. heteroclitum*. Such forms are atypical in being somewhat cut, and in bearing marginal teeth, some of which are quite like the cusps of the *quoyanum* group of species. Such plants are found elsewhere in Mindanao, and more rarely throughout the Philippines, and are likely to be sent in as single specimens, without collector's number. *Weber 1553* from Cagayan Province, in the extreme northern part of Luzon, is typical *C. heteroclitum*, except that it bears a single "juvenile" frond, only 7 centimeters long, which conforms perfectly to the varietal diagnosis.

This variety is of particular interest because the respects in which it deviates from the type lead, on one hand, toward the dwarf species, *Campium cuspidatum* and *C. tenuissimum*, and on the other toward *C. quoyanum* and its numerous relatives. As was partly known to Christ, there are in the Philippines many undescribed and remarkably various dwarfs, locally more or less established, but evidently enough descended from *C. heteroclitum*.

11. CAMPIUM NIGRUM Copeland, sp. nov. Plate 10.

C. gregis C. heterocliti, quo stipite valido paleis angustis atrofuscis usque ad 7 mm longis persistentibus ornato, pinnis viridinigris opacis differt; rhizomate 6 mm crasso; stipitibus haud remotis, 20 cm altis, fulvis; frondis sterilis pinnis utroque latere 2, ca. 12 cm longis, 4–5 cm latis, acuminatis, basibus latis sub-

sessilibus, margine irregulariter crenulato-denticulatis, tenuiter papyraceis sed opacis; venis infra marginem sursumcurvatis et dissipatis, venulis more C. heterocliti anastomosantibus. Fronde fertile non visa.

Ponape, Caroline Islands, *T. Karigone 69*, 1925. Type in the herbarium of the University of California, No. 287252.

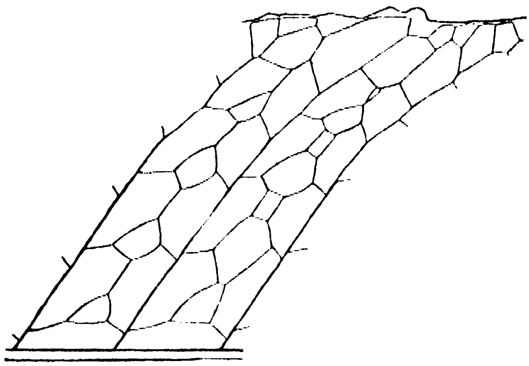


FIG. 14. *Campium nigrum* Copeland, sp. nov.; type.

Certainly very near to *Campium heteroclitum;* but the combination of frond color and opacity and of the striking scaliness of the dark, stout stipes marks it off clearly enough. Except in venation, it is more like the Indian (*flagelliferum*) form than like the common Philippine *C. heteroclitum.*

16. CAMPIUM DIVERSIFOLIUM (Blume) Copeland, comb. nov.

Acrostichum diversifolium BLUME, Enum. Pl. Jav. (1828) 193; Fl. Jav. 2 (1828) 36, pl. 12.

A. frondibus longe stipitatis integerrimis membranaceis glabris parallelo-venosis, sterilibus simplicibus, oblongo-lanceolatis acuminatis, fertilibus ternatis, foliolis lateralibus minoribus obtusis, terminali elongata utrinque acuminata, stipite rachique angulatis glabriusculis.

Crescit in montibus Javae ad ripas fluviorum.—BLUME.

Found throughout Malaya. The type locality is more definitely fixed in Flora Javae as the foot of Mount Burangrang. The type specimen should be in the herbarium of the University of Leyden.

The sterile frond may be simple, as described, and 50 centimeters or more in length; or it may be cleft on one or both sides near the base; or it may have on each side one or two large pinnæ, and a larger terminal leaflet. I have received simple fronds of this, determined as *Leptochilus decurrens,* to which it really bears little resemblance. Its affinity, as Blume recognized, is to *Campium heteroclitum.* On larger fronds

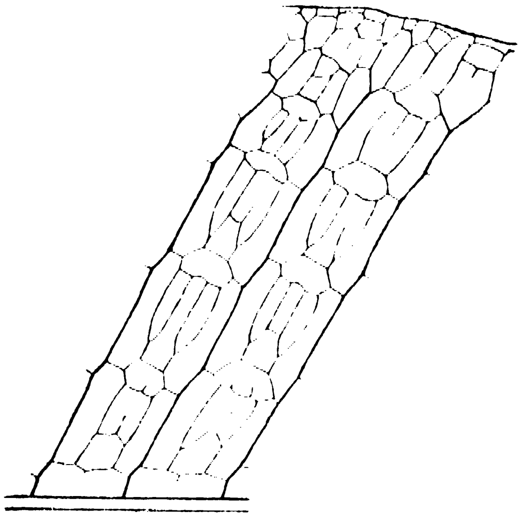


FIG. 15. *Campium diversifolium* (Blume) Copeland, comb. nov.; Java, *Palmer and Bryant 555*.

than the subject of my drawing, the veins are wider-spaced, and the reticulation of the veinlets is less uniform. Specimens from Mindanao (*Copeland 1543*) and from Alabat Island (*Merrill 10469*) are quite intermediate between *C. diversifolium* and *C. heteroclitum*.

16. CAMPIUM PSEUDOSCALPTURATUM Copeland, sp. nov. Plate 11.

Rhizomate repente, fere 1 cm crasso, paleis minutis fuscis vestito; stipitibus, frondis sterilis 30 cm, fertilis 35 cm altis, apud basin paleaceis, sordide stramineis; fronde sterile fere 40 cm alta, ovata, pinnata, pinnis alternantibus, utroque latere ca. 4, inferioribus stipitulatis, lneari-oblongis, maximis medialibus, 15–20 cm longis, 3–4 cm latis, acuminatis, basibus cuneatis, late et oblique inciso-crenatis, herbeceis, laete viridibus, costis stramineis venisque inferne prominentibus, venulis more C. heterocliti anastomosantibus, pinna apicale aliis conforme vel paullo latiore; fronde fertile minore, pinnis 6 cm longis, 8 mm latis.

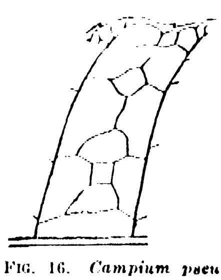


FIG. 16. *Campium pseudoscalpturatum* Copeland, sp. nov.; type.

CAMIGUIN DE MISAMIS, *Bur. Sci. 14816 Ramos*, 1912.

Except that it is somewhat more evidently crenate and that the terminal pinna is not contracted, this has a remarkable super-

ficial resemblance to Fée's plate of *Heteroneuron scalpturatum*. The venation, however, is of the plan of *Campium heteroclitum*, modified as the narrower pinnæ reduce the number of areolæ and in being more lax. The venation, margin, texture, and color of axes and lamina, all mark it as a near relative of *C. heteroclitum*. It is different in the stout rhizome, more numerous pinnæ of very distinct shape, and terminal pinna not lashlike; the last feature is likely to prove not constant, but the others may be presumed to be so.

17. **CAMPIUM FOXWORTHYI** Copeland, sp. nov. Plate 12.

Rhizomate repente, gracile, 1–2 mm crasso, paleis castaneis, linearibus, 1.5–2 mm longis vestito, glabrescente; stipitibus seriatis, gracilibus, viridulis, 5–8 cm longis, praecipue deorsum paleis paucis deciduis vestitis, frondium fertilium paullo longioribus; fronde sterile lanceolata, utrinque angustata, acuminata non flagellifera, interdum prolifera, integra vel superne obscure crenato-denticulata, herbacea, glabra, viride; venis primariis conspicuis, inter eas areolis triseriatis, venulis inclusis normaliter nullis; fronde fertile parva, 2–3 cm longa, lineari-lanceolata, aut integra aut ad basin utrinque pinna vel lobo minuto rotundato praedita.

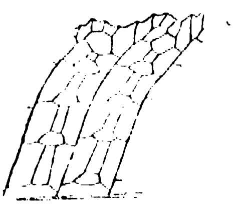


FIG. 17. *Campium foxworthyi* Copeland, sp. nov.; type.

LUZON, Rizal Province, *Bur. Sci. 68 Foxworthy*, 1906. Type in my herbarium.

From this collection number, Christ[15] described *Leptochilus heteroclitus* var. *foxworthyi*, but, at least as to the sterile frond, his description is not of the plant I have. A confusion of specimens or labels must be suspected; for it is not conceivable that Christ regarded this plant, with simple fronds, as "almost exactly intermediate between the type [*heteroclitus*] and the variety *inconstans*."

18. **CAMPIUM TENUISSIMUM** Copeland, sp. nov. Plate 13.

Rhizomate repente, gracile, paleis castaneis 2–3 mm longis vestito; stipitibus brevibus, validis, stramineis, paleis paucis ornatis, frondium sterilium 2–3 cm, fertilium 3–4 cm altis; fronde sterile pinnata, pinnis utroque 1, rarius 2, stipitulatis, oblongis, 1–2 cm longis, obtusis, basi abrupte et oblique cuneatis, interdum basiscopice lobo uno praeditis, obscure denticulatis, herbaceis, venis magnitudinen laminae secundum paucis et irre-

[15] Philip. Journ. Sci. § C 2 (1907) 160.

gularibus, pinna terminale valde elongata, ca. 20 cm longa, 3–4 mm lata, infra apicem prolifera; fronde fertile conforme sed parva, 5–10 cm longa, pinnis lateralibus orbiculari-oblongis, terminale anguste lineare, oblique dense fructifera.

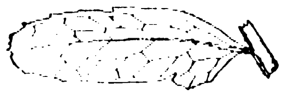


FIG. 18. *Campium tenuissimum* Copeland, sp. nov.: type.

LUZON, Laguna Province, Los Baños, *Copeland s. n.*, 1906. Type in my herbarium.

While very probably evolved by reduction from a larger species, this does not appear to me, in spite of the conspicuous proliferous flagellum, to be too closely related to *Campium heteroclitum* to justify its description as a distinct species.

19. CAMPIUM CUSPIDATUM (Presl) Copeland, comb. nov. Plate 14.

Nephrodium (?) *cuspidatum* PRESL, Rel. Haenk. 1 (1825) 31.

Heterogonium cuspidatum PRESL, Epim. Bot. (1851) 169. Not *Leptochilus cuspidatus* C. Christensen as to other synonyms.

N. frondibus lineari-lanceolatis glabris pinnatis, pinnis oppositis subsessilibus lanceolatis obtusis cuspidato-serratis membranaceis, terminali longissima lineari-lanceolata subradicante.

Hab. in insula Sorzogon. [Sorsogon Province, Luzon.]

Caudex repens teres glaber, radicibus longis flexuosis fibrillosis. Stipes pollicaris filiformis glaber, supra canaliculatus. Frons 3-5-pollicaris glaberrima membranacea pinnata. Pinnae semipollicares brevioresve sesquilineam latae, oppositae aut suboppositae, lanceolatae obtusae serratae, serraturis cuspidatis, basi in petiolum brevem attenuatae, terminali bi-tripollicari lineari serrata, basi lanceolata in petiolum attenuata s. cuneata, apice subinde radicans . . .—PRESL.

The clue to what *Nephrodium cuspidatum* really was, is given in the Epimeliae, where Presl identified it with the smaller and less-divided plants distributed under *Cuming 161*, the subject of the accompanying plate, distinguishing the more ample and more cut specimens as *Heterogonium argutum* Fée. My specimen of this number came with three names: *Cyrtogonium sinuosum* J. Sm. (status juvenalis), which is this form; *Heterogonium argutum* Fée; and *Acrostichum quoyanum* Gaudich., Hook.—the last two should not have been applied to this plant. It is well known that some of Cuming's fern collections from different places in the Philippines were combined under single numbers after they reached England, but before their distribution, with the result that it is not at all unusual for one number to apply to two or more species.

This is a small fern, usually not more than 10 centimeters in total height, with plural pinnæ, usually connected by a wing,

clearly evolved by reduction or arrested development of *Campium heteroclitum.* Depending upon the size of the pinnæ, the veins may be free, as in the accompanying drawing, or they may form a few areolæ.

With this species, I think it proper to combine *Gymnopteris inconstans* Copeland, Perkins' Fragmenta (1905) 178, a form collected many times along Lamao River, near Manila, which differs only in the constantly more entire margin. Christ recognized the affinity of this to *Campium heteroclitum.* The error, which has been prevalent in the identification of *C. cuspidatum* and in not assigning it to the same group, probably goes back to the original confusion of two species in Cuming's collection.

FIG. 19. *Campium cuspidatum* (Presl) Copeland, comb. nov.; *a*, from *Cuming 161*; *b*, from cotype of *Gymnopteris inconstans* Copeland.

20. CAMPIUM QUOYANUM (Gaudichaud) Copeland, comb. nov.

Acrostichum quoyanum GAUDICHAUD, Bot. Freycinet's Voyage (1827) 306, pl. 3.

A. frondibus sparsis (?); sterilibus pinnatis, superioribus confluentibus; pinnis alternis, oblongo-lanceolatis, acuminatis, pinnatifidis; laciniis subfalcatis, obtusiusculis, duplicato-serratis, subciliatis; fertilibus pinnatis; pinnis petiolatis, lineari-lanceolatis, undulato-crenatis, superioribus subconfluentibus.

In insulis Moluccis (Pisang, Rawak, Vagiou, etc.). GAUDICHAUD.

With the recognition of *cuspidatum* as the specific name of a member of another group of species, *quoyanum* becomes the valid specific name of the far commoner fern called *Leptochilus cuspidatus* by Christensen, and in the previous literature most commonly called *Acrostichum repandum* Blume. The dates of publication, given as 1827 and 1828, are so close together that Blume might well have been ignorant of Gaudichaud's species. Blume [16] described in succession, on the same page, *Acrostichum proliferum* from sterile plants and *A. repandum* from fertile, but in another publication [17] he recognized them as the same plant, and figured both fronds. His figure represents a fern less deeply cut and less sharply toothed than typical *Campium quoyanum*, and this is true of all Javan specimens in my hands; but these differences mark it as an established form, rather than make it worth while to try to recognize it as a species. This is a common fern in the Philippines, where the majority of

[16] Enumeration 104. [17] Flora Javae 39, pls. 14 and 15.

specimens are closer to typical *C. quoyanum* than to the Javan form.

With some relatives, this forms a natural group, distinguished from the other species with copiously pinnate fronds by the gradual reduction of the pinnæ, toward the apex, the apical part of the frond, made by the "coalescence" of the upper pinnæ, being pinnatifid at its base, then lobed, and more or less entire near the tip. Proliferation is common in this group, as in that of *Campium heteroclitum*, but not usually among the species that have the terminal leaflet like the lateral ones. The rhizome is typically stouter and more woody than that of *C. heteroclitum*, and evidently of slower growth in length, for the stipes are almost clustered. Associated with this difference is the fact that *C. heteroclitum* is (rarely) found on tree trunks, and not rarely on large bowlders, while *Campium quoyanum* is quite strictly terrestrial.

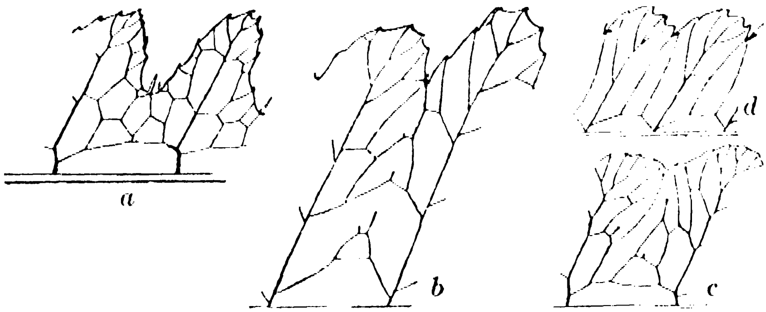


FIG. 20. *Campium quoyanum* (Gaudichaud) Copeland, comb. nov.; *a*, Mindanao, *Elmer 13458*; *b*, *Acrostichum repandum* Blume, Java, *Monsset 140*; *c*, *Campium quoyanum*, China, United States National Herbarium, No. 232248; *d*, near *Campium quoyanum*, Todaya, Mindanao, *Copeland s. n.*

Chrysodium bipinnatifidum Kuhn in the Seychelles represents this group in the West, as *Campium rivulare* and *C. palustre* do in the extreme East, and *Leptochilus taylori* (Bailey) C. Christensen in Australia. Between these geographical extremes, *C. quoyanum* seems to occupy the entire area. Toward the north it reaches southern China and Formosa and is reported from the Riu Kiu Islands. I cannot distinguish *Chrysodium naumanni* Kuhn, described from New Hanover, sufficiently to care to transfer the name. I have what seems to be this, from Papua, collected by C. King, and from Kaiser-Wilhelms Land, collected by Schlechter.

The sterile fronds of *C. quoyanum* are 30 to 50 centimeters long, on stipes 20 to 30 centimeters long. The stalked pinnæ,

half a dozen to a dozen or more pairs, are 8 to 15 centimeters long, 15 to 30 millimeters wide, acuminate, truncate at the base but usually less abruptly on the lower side; the margin is cut one-fourth to one-half of the way to the costa, forming toothed lobes, with or without bristles in the sinuses; if narrow, the lobes tend to be falcate; the lamina is thin, clear green, and glabrous, but the rachis is persistently slightly scaly. The fertile frond is similar in length, but the pinnæ are shorter, much narrower, and commonly sinuate instead of lobed. Rosenstock's variety *marginatum* [18] has unusually broad fertile pinnæ with the sporangia restricted to a marginal band. If the species were distinct, this should be referred to *C. naumanni*.

A rare Philippine form with deeply and permanently red sporangia is represented by *Cuming 294* (*Cyrtogonium laciniatum* J. Smith), from Leyte, and by *Elmer 13468* in part, from Mindanao.

Within the range of *Campium quoyanum*, it seems expedient to recognize as distinct the northern Luzon form to be described next. I have also a single plant from Todaya, Mindanao, altitude 800 meters, with sterile frond of the same general form as *Acrostichum repandum*, short, entire fertile pinnæ, the venation shown herewith, and some minor differences. It is probably a distinct species, but may await description until found again.

HETERONEURON SINUOSUM Fée.

Heteroneuron sinuosum FÉE, Acrost. (1845) 95, pl. 55, fig. 2.

Frondibus sterilibus pinnatis, rhachi squamis raris ferente, frondulis anguste lanceolatis, suboppositis alternisque, basilaribus petiolatis, ultimis sessilibus, repando-sinuatis, sinubus nervilla brevi instructis, apice acuminatis, basi acutis, terminali longiori, in acumine elongato desinente, petiolo longo, anguste canaliculato.

Habitat in Philippinis. Cuming nos. 105 et 161 in herb. Vindob. non alibi.

Dimensions: La longueur totale des frondes fertiles, les seules que nous connaissions, atteint 45 centim., mesure prise à la base de la frondule terminale; celle-ci a près de 14 centim., sur 15–18 millim. de large; le pétiole égale la lame en longueur. Nous avons sous les yeux des spécimens un peu plus petits, avec des sinus moins marqués.—FÉE.

Very evidently, it was not the fertile, but the sterile fronds that alone were known by Fée. *Cuming 105* in the United States National Herbarium is this plant, but *Cuming 161* in that herbarium is Fée's *Heteroneuron argutum*. I have collected this fern (*H. sinuosum*), young and sterile, near Pagsanjan,

[18] Fedde's Repert. 9 (1911) 426.

Laguna Province, Luzon, and with it another, adult but having lost its fertile pinnæ, intermediate between this and *Campium quoyanum*. The young plant is decidedly reddish, as is less conspicuously true of the Cuming specimen, but not of my adult plant. An approach to this fern is presented by some of the very aberrant plants referred to *C. heteroclitum*, but the affinity to *C. quoyanum* is the more evident. This looks like a distinct species, but I am not giving it a name in *Campium* until fertile specimens may establish its status better.

FIG. 21. *Heteroneuron sinuosum* Fée; cotype.

21. CAMPIUM VALIDUM Copeland, sp. nov. Plate 15.

Rhizomate lignoso, 1 cm crasso, paleis parvis fuscis obtecto; stipitibus, frondis sterilis 30 cm, fertilis 45 cm altis, validis, brunneis, pedibus paleaceis, alibi nudis; fronde sterile 40 cm alta, ovato-lanceolata, rhachi brunnea; pinnis utroque latere 15, inferioribus brevipedicellatis, fere 10 cm longis, 2 cm latis, acutis, basi truncatis subobliquis, inciso-lobatis, sursum gradatim minoribus et obtusis, segmento apicale frondis e pinnis coadunatis composito parvo, ca. 8 cm longo, acuminato, prolifero; venis more *C. quoyani* anastomosantibus; frondis fertilis pinnis paucis, aequalibus, fere 10 cm longis, 15–20 mm latis, profundius lobatis.

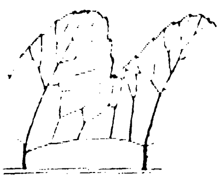


FIG. 22. *Campium validum* Copeland, sp. nov.: type.

LUZON, Cagayan Province, *Bur. Sci. 13807 Ramos*, 1912.

One of the group of *Campium quoyanum*. The fertile frond is remarkable enough to be suspected of being a monstrosity. The sterile frond differs from that of common *C. quoyanum*, in its naked axes, more numerous and blunter pinnæ, regularly decreasing in size toward the apex, and in the small and narrow apical segment.

22. CAMPIUM SUBCORDATUM Copeland, sp. nov. Plate 16.

C. gregis C. quoyani pinnis basi plus minus cordatis; rhizomate repente, 1 cm crasso, apice paleis nigro-castaneis late lanceolatis integris acuminatis 2–3 mm longis vestito; stipite frondis sterilis usque ad 40 cm alto, fusco-fulvo, sordide squamuloso, sursum rhachique superne bisulcatis; fronde sterile (exempl. visorum) 35–40 cm longa, 20–30 cm lata; pinnis utroque latere ca. 7, medialibus 15 cm longis, 3.5 cm latis, plerisque falcato-caudatis, subsessilibus, basi subcordatis vel solummodo

truncatis, leviter crenato-lobatis lobis crenulatis sinubus saepe setiferis, tenuiter papyraceis, costis fulvis inferne praestantibus; areolis inter venas primarias pluriseriatis vel irregularibus, areola infima quae nec costam nec venas attingit venulam unam simplicem excurrentem includente, liberis inclusis alibi, ob imperfectionem reticulationis, haud carentibus; pinnis infimis oppositis paullo latioribus basiscopice rotundatis; foliola terminale majore, profundius falcato-lobatis, sub apice prolifera; fronde fertile angustiore, 30–40 cm longa vix 10 cm lata; pinnis utroque latere 7–10, remotis, ca. 6 cm longis, vix 1 cm latis, obtusis, basi truncatis, crenato-undulatis.

Hainan, southern slope of Five Finger Mountain, *McClure, Canton Chr. Coll. 9436*. Type in the herbarium of the California Academy of Science, No. 91888. Also in the same herbarium, No. 9346.

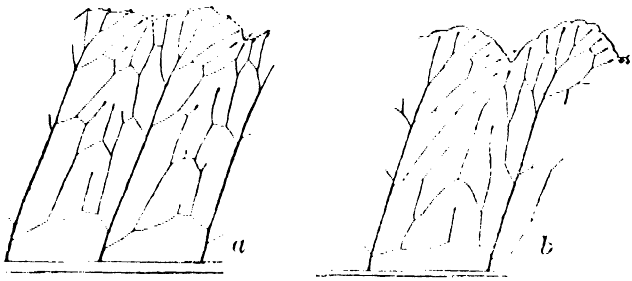


FIG. 23. *Campium subcordatum* Copeland, sp. nov.: *a* type; *b*, cotype.

Sterile specimens from Hong Kong (*Oldham*) and Chekiang (*H. H. Hu 156*, 1920) probably are this species, but are not mature or complete enough for positive determination. Fu Kien specimens, *Norton 1058* and *1059*, are likewise sterile, but quite positively belong here. Specimens from Hainan, *Eryl Smith 1641*, and Hong Kong, *Wright s. n.*, are likewise referred here, though the fertile pinnæ are smaller than those described, and the lateral sterile pinnæ are toothed but not lobed.

23. **CAMPIUM INTERLINEATUM** Copeland, sp. nov. Plate 17.

Rhizomate lignoso, 6 mm crasso; stipitibus approximatis, frondis sterilis 35 cm, fertilis, 45 cm altis, rhachibusque brunneis, sordide furfuraceis sursum glabrescentibus; fronde sterile 50 cm longa, 25 cm lata, pinnata; pinnis utroque latere ca. 8, brevipedicellatis, majoribus 15 cm longis, 35 mm latis, falcato-caudatis, basi truncatis vel superioribus latere acroscopico cuneatis caudam versus falcato-crenatis rhachin versus undulatis,

papyraceis, rubido-tinctis, segmento treminale latiore subinciso; venis usque in lobos marginis protensis; venulis more C. quoyani anastomosantibus, sed ob magnitudinem et texturam firmiorem frondis reticulationem ampliorem efficientibus, cum liberis inclusis haud paucis venam spuriam inter veras simulantibus, fronde fertile conforme, pinnis ca. 6 cm longis, 8 mm latis, integris.

Borneo, Sarawak, Bungo Range, *C. J. Brooks 12*, 1909.

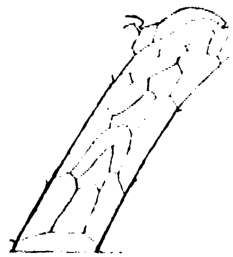


FIG. 24. *Campium interlineatum* Copeland, sp. nov.; type.

This has the frond form of a large *Acrostichum repandum*, but the texture and the venation are distinctive. The reddish caste suggests *C. scalpturatum*, but the venation is very different.

24. CAMPIUM PALUSTRE (Brackenridge) Copeland, comb. nov. Plate 18.

Cyrtogonium palustre BRACKENRIDGE, U. S. Expl. Exped. 16 (1854) 86, pl. 12, fig. 2.

C. terrestre; stipitibus semiteretibus sulcatis parce paleaceis; frondibus membranaceis glabris pinnatis apice sinuato proliferis; pinnis oblongo-lanceolatis pinnatifidis acuminatis basi oblique cuneatis, laciniis oblongis crenato-denticulatis, fertilibus minoribus oblongo-lanceolatis petiolatis integris.

Hab. Tahiti, Society Islands: in marshy grounds near the coast.

Stipes from 10 to 12 inches in length, *half-round*, with 2 to 3 shallow grooves in front, densely *paleaceous* at the base, towards the summit less so; the paleae oblong, acuminate, reticulate, with a ragged dentate margin. Sterile *fronds* deltoid-oblong, acuminate, *rooting at the apex, smooth, rather membranaceous, pinnate* at the base, *sinuate-pinnatifid* towards the point. Inferior pinnae 4 to 5 inches long and an inch broad, subpetiolate, nearly opposite, *oblong-lanceolate, acuminate, pinnatifid*, with an *oblique cuneate* base; the middle ones adnate and decurrent; while those toward the point are confluent, entire, subfalcate and obtuse. *Segments oblong* or triangular-ovate, the margin denticulate, with a single stiff hair seated at the base of the sinus. *Fertile fronds narrower*, with from 11 to 16 pinnae . . . Veins prominent on both sides, the anastomosing veinlets slender.—BRACKENRIDGE.

From the number of collections, this seems to be a common fern in Tahiti and Samoa. As in various other proliferous species, the apex is variable, sometimes forming a long narrow rooting tail. Samoan specimens too similar to seem specifically different have the sterile pinnæ uniformly wider, more conspicuously falcate-caudate, more deeply cut with narrow, subfalcate lobes, and more numerous areolæ in the uncut lamina.

The terminal segment may be short, 5 to 10 centimeters long, contracted from a broad base, through a short, lobed portion of a few lobes, to a short tail; or it may be drawn out, as in the more attenuate forms of *Campium heteroclitum*, into a sinuate or lobed lash, 25 centimeters or more in length. The pinnæ normally bear a visible excrescence at about the base of the narrow apex of each, showing potential proliferation. A Samoan specimen, collected by Francis C. Prince in 1898, has the tails of the pinnæ drawn out to 5 centimeters or more, and the majority of them bear well-developed little plants.

FIG. 25. *Campium palustre*

(Brackenridge) Copeland, comb. nov.; Tahiti. *Setchell and Parks 435.*

New Caledonia specimens, *Rosenstock Fil. Nov. Cal. 31*, distributed as *Leptochilus quoyanum*, but better to be called *Campium palustre*, have the lowest pinnæ strongly developed on the lower side, and the veins anastomosing less freely than is typical. I think it very possible that these represent *Chrysodium sagenioides* Kuhn, and abstain from reducing that species to *Campium palustre* chiefly because of Kuhn's description of the venation. *Campium palustre* is represented from Queensland by a specimen collected by Dietrich, United States National Herbarium, No. 269584, distributed "ex museo Godefroy Hamburgensis" as *Chrysodium cuspidatum* Kuhn.

25. **CAMPIUM SAMOENSE** Copeland, sp. nov. Plate 19.

Species gregis C. quoyani; rhizomate repente, paleaceo, 5 mm crasso; stipite frondis fertilis 50 cm alto, gracile, fulvo, ad pedem paleis fusco-fulvis lanceolatis 3–5 mm longis vestito, alibi rhachique glabrescentibus; frondis sterilis verisimiliter parte solummodo in manubus 30 cm longa, ultra 20 cm lata, pinnis inferioribus 13 cm longis, 2–2.5 cm latis, basi subsessilibus utrinque late (et basiscopice latius) cuneatis, apice caudatis cauda breve aut recta aut falcata anguste lineare late crenata, margine oblique haud profunde inciso-lobatis lobis integris sinubus acutis interdum dente spiniforme munitis, membranaceis, quoad laminam glabris, brunnescenti-viridibus, costis gracilibus inferne paleis minutis ornatis, venatione C. quoyani venulis tenuissimis inferne conspicuis; segmento terminale frondis breve, pinnatifido lobis ovatis falcatis, in caudam 25 mm longam in specimine non proliferam desinente; fronde fertile 30 cm longa, 15 cm lata, apice composita, pinnis utroque latere ca. 10, infimis 9 cm longis, 9 mm latis, stipitulatis, longe sensim acuminatis,

deorsum late crenatis cum spina in sinu quoque, superioribus integris vel similiter spiniferis absque crenatione ulla, inferne tota latetudine sporangiis obtectis.

Samoa, *Rev. T. Powell.* Type in the Gray Herbarium.

A relative, more particularly, of *Campium palustre,* as indicated by the oblique lobes, but differing in the broader base of the longer, narrower sterile pinnæ with parallel sides, less abruptly narrowed to narrower, shorter, nonentire tips, conspicuous veinlets, brownish green color, and most conspicuously in the long, narrow, fertile pinnæ. From *Campium quoyanum*, it differs in the more cuneate base of the sterile pinnæ, shallow, entire lobes, and long-pointed, more entire, fertile pinnæ.

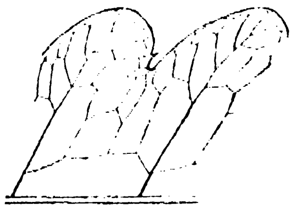


FIG. 26. *Campium samoense* Copeland, sp. nov.: type.

26. CAMPIUM RIVULARE (Brackenridge) Copeland, comb. nov. Plate 20.

Cyrtogonium rivulare BRACKENRIDGE, Bot. U. S. Expl. Exped. 16 (1854) 85, pl. 11, fig. 2.

C. rhizomate repente; stipitibus angularibus paleaceis; frondibus membranaceis glabris oblongis attenuatis basi pinnatis versus apicem sinuato-pinnatifidis, fertilibus minoribus; pinnis integris oblongo-lanceolatis vel ovatis obtusis subfalcatis apice proliferis.

Hab. Ovalau, Feejee Islands: banks of streams, on wet rocks, in shady places.

Rootstock creeping, about the thickness of a goosequill, and paleaceous; the paleae reticulate, ovate-oblong, attenuate, dentate. *Stipes angular,* slightly furrowed, 4 to 5 inches long; that of the fertile frond 12 to 14 inches long, and, together with the rhachis, bearing slender *rufous paleae. Sterile fronds* 8 to 10 inches long, smooth and *membranaceous, oblong, attenuated,* the base *pinnate,* towards the apex *sinuato-pinnatifid,* the latter with the obtuse points of the pinnae *proliferous. Fertile fronds small,* not exceeding 4 inches in length, with the points of the *pinnae oblong lanceolate or ovate,* more rounded than in the sterile ones.—BRACKENRIDGE.

As this is not represented among the numerous Fiji ferns in local herbaria, I conclude that it is not common; but this kind of question, as to Fiji, is expected to be answered by the careful collection now undertaken by the Bishop Museum.[19] Brackenridge's plate shows a very distinct species, with a single pair of free pinnæ; less than half of the lobes of the body of the frond are proliferous.

[19] These collections are now in hand and show that *Campium rivulare* is a clear-cut and distinct species, but that in its full development it has many pinnæ and is not remarkable for the production of numerous buds. Venation and shape of pinnæ are substantially as described by Brackenridge.

Beside the type, the only specimen I have seen is a sterile one from Fiji, *Horne 694*, in the Gray Herbarium, collected in 1877–1878. It has one pair of stipitulate pinnæ, the next two or three pairs adnate, and the rest of the frond coadunate, lobed or pinnatifid but not nearly to the costa. It is much broader than the specimen figured by Brackenridge, the basal pinnæ reaching a length of 10 centimeters. Also, no pinnæ are actually proliferous. Still, the almost entire bluntish pinnæ and lobes, the large, shallowly lobed or pinnatifid upper part of the frond, and the venation make the identification positive. The main veins are very weakly developed.

27. **CAMPIUM NEGLECTUM** (F. M. Bailey) Copeland, comb. nov.

Acrostichum neglectum F. M. BAILEY, Proc. Linn. Soc. N. S. Wales 5 (1881) 32; Syn. Queensland Flora (1883) 722.

Rhizoma squamosum, fuscum, durum, Lomariae simillimum, frondibus fertilibus et sterilibus 1′ ad 3′ alt. lanceolatis, profunde pinnatifidis, segmentis angustis, linearibus, marginatis. Stipite frond. steril. alibus dentatis vel lobatis marginatis, segment. lanceolatis, serratis, dentibus serratis vel aculeatis, long. 3″ ad 6″, lat 6‴ ad 9‴. Alae supradictae lat. 6‴. Venis ut in A. repandum.

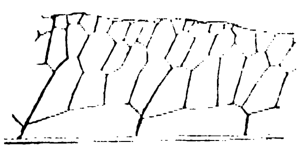


FIG. 27. *Campium rivulare* (Brackenridge) Copeland, comb. nov.; Fiji, *Horne 694*.

In vallis perumbrosis, Trinity Bay Range.

Rhizome creeping, scaly, dark coloured, hard. Fronds of two kinds like a *Lomaria*, one to three feet high, lanceolate in outline, deeply pinnatifid, stipes in the fertile frond more than half its length, and bordered by a narrow wing . . . Stipe of the sterile frond half the length of frond, bordered by a toothed or lobed wing to the base . . . —BAILEY (1881).

The English translation is copied verbatim in the synopsis of the Queensland Flora.

Icones: Hooker's Ic. Plant. III 7: pl. 1689, with a modified Latin description; Bailey, Lithograms of the Ferns of Queensland, pl. 185.

Bailey, beside noting a resemblance to his *Acrostichum repandum*, refers to a specimen so named in the herbarium of J. Smith. Baker says "it comes nearest to the widely spread A. virens." It differs from either of these conspicuously enough to make me suspicious as to the genus.

28. **CAMPIUM TAYLORI** (F. M. Bailey) Copeland, comb. nov.

Acrostichum Taylori Bailey, Rep. of Ql. Accli. Soc. April, 1884. Fronds scaly, somewhat tufted from a short, creeping, knotted rhizome, stipes of fertile fronds from under 2 inches to 5 inches long, slender, those of the sterile fronds usually shorter; fronds pinnate in the lower, pinnatifid in the upper part, and usually terminating in a narrow, tail-like, proli-

ferous apex; pinnae obtuse-oblong, very irregularly lobed, 1 to 3 inches long, 3 to 9 lines broad. Veins forming a row of long costular areoles, the rest free to the margin.

Hab.: On wet rocks, Johnstone River.

Very near *A. repandum* Bl., but a much smaller plant with a closer habit.—F. M. BAILEY, Synop. Queensland Fl. Suppl. 1 (1886) 65.

Not seen. So far as explicit statements go, nothing in the foregoing description except the "closer habit" would distinguish this from *Campium argutum*, which is very lax in its fully developed form. Bailey [20] figures this, showing rounded apices of pinnæ and lobes; the pinnæ lobed a third of the way to the costa or the basal ones half-way; lobes about four on each side, almost entire except for the tooth in the sinus; pinnæ, three pairs stalked and one pair adnate, below the pinnatifid apex, which is half of the length of the frond.

29. CAMPIUM PARVUM Copeland, sp. nov. Plate 21.

C. nanum gregis C. quoyani, rhizomate repente, 2 mm crasso, paleis fuscis ovatis, acuminatis, 1 mm longis obtecto; stipitibus seriatis, gracilibus, minute sparse paleatis, frondis sterilis usque ad 4 cm, fertilis ad 9 cm altis; fronde sterile 5–6 cm longa, ovato lanceolata, pinnata, rhachi anguste alata, parte terminale e pinnis coadunatis confecta; pinnis utroque latere 2 vel 3, infimis stipulatis, late ovatis, obtusis vel rotundatis, basi dilatatis sed decurrentibus, interdum obscure paucilobatis, irregulariter dentatis dentibus rarissime apiculatis; venis inconspicuis, extra areolas costales irregulariter anastomosantibus, venulis liberis inclusis nullis; fronde fertile conforme minore, 3.5 cm longa, 1.5 cm lata, pinnis infimis sinuato-lobatis.

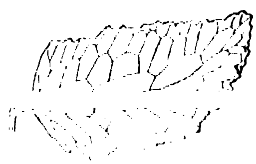


FIG. 28. *Campium parvum* Copeland, sp. nov.; type.

Kaiser-Wilhelms Land, in mountain woods, altitude 300 m. s. m., *Schlechter 16163*, 1907. Type in the herbarium of the University of California, No. 226411.

This was distributed as *Leptochilus inconstans*, which it resembles in hardly any respect independent of size. This is certainly one of the *C. quoyanum* group, as shown particularly by the fused pinnæ composing the upper part of the frond. The single pinnæ are too small to develop main veins, but the larger, upper part of the frond shows the venation of the pinnæ of the larger species of the group.

[20] Lithograms of the Ferns of Queensland (1892) pls. 183, 184.

A sterile specimen from Papua, *King 269*, 1909, is possibly the same as this, but its stipes are persistently densely scaly.

30. CAMPIUM ARGUTUM (Fée) Copeland, comb. nov. Plate 22.

Heteroneuron argutum FÉE, Acrost. (1845) 96, pl. 25, fig. 2.

Frondibus sterilibus basi bipinnatifidis, apice pinnatis, frondulis basilaribus laciniis suboppositis, curvatis, inciso-dentatis, dentibus argutis, rhachi subnudo, plano; fertilibus pinnatis, pedicellatis, frondulis in apice ovato coalitis, primariis pinnatifidis, petiolo universale (rhachi) plano; rhizomate repente, flexuoso, fibrilloso, crassitie pennae columbae; sporangiis rotundis, late pedicellatis, annulo 13 14 articulato, sporis magnis, rotundatis, episporio persistente.

Habitat in Manila, nec non in Philippinis, Luçon (Cuming).

Exsiccatum: Cuming no. 161, non no. 105.

. . . M. Kunze, qui a vu notre spécimen, le déclare jeune.—FÉE.

This has remained a doubtful species since the time of Fée, except for additional and accurate notes by Presl,[21] who called attention to the mixture under Cuming's number. *Cuming 161* in the United States National Herbarium is typical. Probably the same as this are plants recently brought in by Dr. F. T. McLean. Because these represent the plant in a really mature form, on which the description ought to be based, a description fitting them follows:

Rhizomate repente, 2–3 mm crasso, paleis nigro-fuscis parvis tecto; stipitibus approximatis, sordide stramineis, frondium sterilium 20 cm, fertilium ca. 35 cm altis, paleis paucis angustis 3–5 mm longis aliisque minutis vestitis, glabrescentibus; fronde sterile ca. 25 cm longa, ovata, subbipinnata, lamina glabra, herbacea, laete viride; pinnis liberis ca. 6-paribus, infimis longe (1 cm) stipitulatis, caudatis, profunde pinnatifidis, lobis obtusis, falcatis, serrulatis, infimo interdum libero (deinde pinnula), sinu quoque unilateraliter dente uno acuto ornato, parte apicale frondis e segmentis coadunatis composita, frondibus visis non proliferentibus; venulis ob dissectionem frondis saepe liberis, areolis paucis et irregularibus; pinnis fertilibus crenato-sinuatis, 2–4 cm longis, 3 mm latis, infimis interdum majoribus et pinnatifidis.

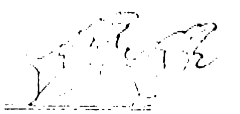


FIG. 29. *Campium argutum* (Fée) Copeland, comb. nov.

LUZON, Cagayan Province, Claveria, *McLean, Catalan, and Peralta s. n.*, 1920, *McLean and Catalan s. n.*, 1919.

A member of the group of *Campium quoyanum* as to conspicuous characters, differing from that species in the greater dissection, and in the narrower and more uniform pinnæ.

[21] Epim. 169.

31. **CAMPIUM BIPINNATIFIDUM** (Mettenius) Copeland, comb. nov.

Chrysodium bipinnatifidum (Boivin) METTENIUS in Kuhn, Fil. Afr. (1868) 50.

Rhizoma repens, validum, paleis lanceolatis, fuscis squamosum; folia membranacea, firma, supra opaco-viridia, infra ad costas paleis paucis squamulosa, sterilium petiolus 5″ longus, stramineus, rhachis marginata; lamina 9″ longa, ovata, acuminata, pinnatisecto-pinnatipartita s. basi deorsum subbipinnatisecta; supra sub apice e costa prolifera; segmenta patentia, e basi inaequali, superiore truncata s. subcordata, inferiore cuneata s. rotundata, elongata, attenuata, infima brevi petiolulata, superiore basi deorsum adnata s. decrescentis, suprema in apicem pinnatifidum confluentia, lobi laciniaeve ala manifesta coadunatae, semioblongo ovatae s. elongato-oblongae, serratae; dentes herbacei, obtusi s. acuti, basales interni ad sinus loborum maximi; nervi in pagina inferiore manifesti, catadromi; maculae ad sinus laciniarum bi-subtriseriatae, secus costulas uniseriatae. Ins. Sechellae (Boivin).—Ins. Borboniae (Boivin).—KUHN.

I now think that this can safely be regarded as a species distinct from the Asiatic and Polynesian *L. cuspidatus* C. Chr. (*Acrostichum repandum* Blume). It differs in the more deeply cut pinnae, which are truncate at the base, not cuneate, and in the more decidedly scaly costae. The lowermost pinnae are rather unequal-sided, the upper ones decurrent at the lower base, and the fertile pinnae deeply cut into bluntly rounded lobes. The sterile fronds often have rooting tips. —CHRISTENSEN, Trans. Linn. Soc. Bot. 7 (1912) 414.

These distinctions may apply to the *repandum* form better than to typical *C. quoyanum*.

This is the most western species of its group.

A specimen from the Seychelles in the Gray Herbarium conforms perfectly with Mettenius's description in all respects except size, being more than 40 centimeters long (the sterile lamina), and also broadly ovate. The lowest two or three pairs of pinnæ are stalked, the middle ones adnate on the lower side, and in the upper third of the frond coadnate, but connected by a narrow wing. The lowest ones are narrowed to the base, with a single small, oblong, almost free segment. In general aspect, it suggests a *Pleocnemia*. However clearly a member of the same group, it is very distinct from *Campium quoyanum*, and, because of the deep dissection of the pinnæ, especially so from the Javan, *repandum*, form. It is distinguishable from all other known species by the broad areolæ, with free included veinlets, between the sinuses and the costa. In the specimen referred to, the subject of the accompanying drawing, these

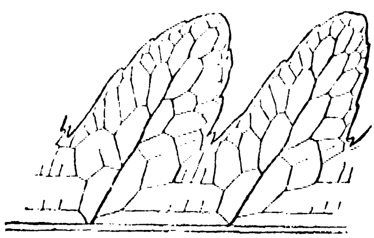


FIG. 30. *Campium bipinnatifidum* (Mettenius) Copeland, comb. nov.; Seychelles

areolæ are further remarkable because of their free included veinlets. These veinlets are almost wanting in a United States National Herbarium specimen, No. 815186, collected by Neville, which has the frond longer, not quite so wide, less dissected, and terminating in a linear lash more than 20 centimeters long, proliferous at both apex and base.

32. CAMPIUM BOIVINI (Mettenius) Copeland, comb. nov.

Chrysodium boivini METTENIUS in Kuhn, Fil. Afr. (1868) 51.

Rhizoma?; folia chartacea, opaco-viridia, glabra; sterilium petiolus 9″ longus, livido-stramineus; lamina 10″ longa, ovato-acuminata, pinnatisecta, apice pinnatifida, supra sub apice prolifera; segmenta 3–4-juga, approximata, patentia, lanceolato-oblonga, acuminata, integerrima, infima breviter petiolata, basi superiore truncata, inferiore cuneata, superiore brevius petiolata vel basi inferiore decurrente adnata, utrinque cuneata, suprema in apicem basi pinnatipartitum confluentia, aciniis 3-jugis, sinubus acutis distinctis, oblongis, acuminatis falcatis, infimis, maximis decurrentibus; costulae manifestae, vix prominulae, maculae utrinque ad costam irregulariter 3–5-seriatae, costulae amplae, plerumque appendiculatae, ceterae appendiculatae vel radiatae vel in maculas secundarias divisae; arcus Pleocnemiae inter lacinias coadunatas, exappendiculatas, macularum series ad sinus laciniarum 2–3 irregulares appendiculatae; fertilium? (Mett. msc.)

Ins. Comorae; ins. Mayotte (Boivin).—Angola (Welwitch, Iter Angolense n. 156).—KUHN.

Since reported from the Belgian Congo and elsewhere in Africa. According to Engler [22] *Acrostichum laurentii* Christ is identical with this.

I have seen no specimen. It is placed in the *quoyanum* group because a fern pinnate below and pinnatifid at the top seems to belong there. The group is represented positively in the Seychelles by *Campium bipinnatifidum*.

33. CAMPIUM SEMICORDATUM (Moore: Baker) Copeland, comb. nov. Plates 23 and 24.

Acrostichum semicordatum BAKER, Syn. Fil. (1868) 422.

Rhizome woody, short-creeping; *st.* of barren fr. 6–8 in. l., erect, nearly naked; *barren fr.* 8–12 in. l., 3–4 in. br., sometimes proliferous at the apex; lower *pinnae* 2–3 in. l., ½–⅝ in. br., the edge inciso-crenate throughout, the base cordate on the upper, truncate on the lower side; *texture* herbaceous; *surfaces* naked; *veins* fine, the main ones distinct about halfway to the edge, the *areolae* in 3–4 rows, with free veinlets; *barren pinnae* (this surely should read *fertile*) distant, 1–1½ in. l., 1 lin. br. *Poecilopteris semicordata, Moore. Hk. 2nd Cent. t. 88.*

Hab. Concan, *Law;* Neilgherries, *McIvor;* Ceylon, *Thwaites 3075.*—BAKER.

[22] Pflanzenwelt Africas 16.

The illustration in Beddome[23] is a drawing by Baker from McIvor's collection, which does not conform well to the written description. The margin of the sterile pinnæ is depicted as finely and acutely serrate, more so than any specimen I ever saw in the genus; the venation is drawn with uniformly two rows of areolæ, and the fertile pinnæ as drawn are up to 5 millimeters in width. There is also a detail drawing of the fructification, representing the sporangia as confined to a broad middle zone, with the margins sterile. Beddome had never seen such a fern, but suspected it of being a form of what he called *Poecilopteris contaminans*.

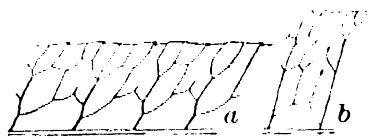


FIG. 31. *Campium semicordatum* (Moore: Baker) Copeland, comb. nov.: *a*, cotype: *b*, India, *Beddome*.

I have from the Gray Herbarium, but not from Kew, a specimen, the subject of the right half of the accompanying Plate 23, which I construe as a cotype of this species, Law's collection being the first cited by Baker. I do not try to decide wether or not the other specimens cited by Baker are the same; but, if I ever see a fern with the fertile frond as it is figured in the Beddome plate referred to, I will consider it distinct.

With this, I identify a fern collected by Beddome, which I considered different before receiving the Law specimen. To give a more complete idea of the species, I will still publish the description and plate prepared while I deemed it distinct.

Rhachi paleis minutis atrocastaneis persistentibus sparse vestita; frondis sterilis pinnis multis, fere contiguis, late lanceolatis, acutis vel acuminatis, minute et obtuse serrulatis, basi obliquis acroscopice rotundatis basiscopice cuneatis, viridibus, papyraceis, foliola terminale moderatim elongata, crenato-lobata; costa inferne prominente; venis inconspicuis; venulis reticulum areolarum typice triseriatarum (vena ad venam) efficientibus sed hic illic infra confluentiam normalem desinentibus, liberis marginem versus (nec usque) currentibus brevibus, clavatis.

India, Anamallay, altitude 600 to 1,200 m. s. m., *Capt. Beddome*.

This is probably a very common Indian fern, without an early valid name because of long confusion and misidentification. I take this to be *Acrostichum contaminans* of Beddome, at least in large part, and of Wallich, as represented by a specimen of his No. 22 sent me from Kew, but not as interpreted by Clarke.

[23] Ferns of British India pl. 270.

I also take it to be the fern repeatedly called *Acrostichum repandum,* illustrated by Beddome;[24] but it is not at all *A. repandum* Blume. Less confidently, I take it to be *Polybotrya prolifera* Bory, *Heteroneuron proliferum* Fée, Acrost. pl. 55, fig. 1; but this name is preoccupied in *Campium* by Presl's transfer of *A. proliferum* Hooker, which is a synonym of *C. subcrenatum* and a homonym of *A. proliferum* Blume. *Acrostichum terminans* Wallich, List No. 2168/1, is this or a very nearly related species; it has a very elongate apex, bearing exceedingly many little lobes or, in its lower part, pinnæ.

34. **CAMPIUM LANCEUM** Copeland, sp. nov. Plate 25.

Rhizomate repente, 1 cm crasso, paleis fuscis anguste lanceolatis 3–4 mm longis vestito; stipitibus approximatis, 60–70 cm altis, sursum rhachique trisulcatis, decidue squamulosis, fulvo-stramineis; frondis sterilis parte inferiore solummodo visa 30 cm longa; pinnis suboppositis, valde (5–8.5 cm) inter se remotis, longe (infimis 15 mm) pedicellatis, 25–30 cm longis, 25–30 mm latis, basi subaequaliter anguste cuneatis, apice sensim longe attenuatis et ibidem dentibus appressis apiculiformibus praeditis haud proliferis, margine alibi crenato-undulatis, laete viridibus, glabris, papyraceis; costa utraque facie prominente; venis infra marginem dissipatis, areolis quae nec costam nec venas attingunt irregulariter 1–2-seriatis, venulis liberis inclusis paucis; fronde fertile 30–40 cm longa; pinnis utroque latere ca. 10, brevius stipitulatis, usque ad 10 cm longis, 3 mm latis, integris, terminale conforme elongata, gemmulifera.

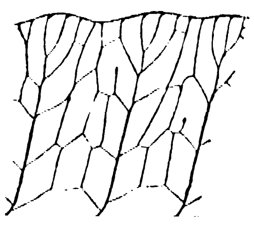


FIG. 32. *Campium lanceum* Copeland, sp. nov.: type.

Madras, Rumpa Hills, altitude 900 m. s. m., *Gamble 15921.* Type in the Kew Herbarium.

This seems to have been distributed as *Gymnopteris subcrenata* Hooker and Greville, from which the slender, long-stalked, sharp-based sterile pinnæ and very different venation mark it off clearly. In much the same respects it differs from *Campium semicordatum,* to which it seems rather closer. The old species to which it is really near is *C. undulatum,* to which, if without any respect for the peculiarities of fertile fronds, I might refer it.

[24] Ferns of Southern India pl. 202.

35. **CAMPIUM ANGUSTIPINNUM (Hayata) Copeland, comb. nov.**

Leptochilus angustipinnus HAYATA, Icones Fl. Form. 5 (1915) 297, fig. 119.

Leptochilus cuspidatus var. *crenatus* ROSENSTOCK, Hedw. 56 (1915) 348; HAYATA, Icones 8: 150.

Rhizoma? Frons sterilis: Stipes 30 cm. longus medio 2½–3 mm. latus basi minute densiuscule squamatus, squamis polygono-oblongis subamoeboideis 1 mm. longis ½ mm. latis, stramineus plano-convexus in sectione supra planus subtus convexus supra 4–5 sulcatus; frons ovato-triangularis 45 cm. longa 30 cm. lata medio latissima basi minus lata vel aequilata vel latior apice caudato-acuminata basi in ambitu truncata pinnata, pinnis linearibus infimis 16 cm. longis, pinnis mediis subaequilongis superioribus gradatim brevioribus minoribus, versus apicem frondis ad pinnas laterales superrimas minimas 4–5 cm. longas abeuntibus; pinna terminali subito longior pinnas superrimas laterales in longitudine 3–4-plo superanti vel interdum perfecte obsoleta et ad prolem reducta; pinna infima lineari 15–16 cm. longa 2 cm. lata apice gradatim acuminatissima, acuminibus minus quam 3 mm. latis 2 cm. longis, medio deorsum aequilata basi late triangulari-acuta margine repandula, repandulis mediis 4 mm. latis 1½ mm. longis apice rotundatis plus minus ascendentibus; pagina membranacea vel tenuiter chartacea supra glabra subtus ad vel prope costas leviter tenuiterque minute squamata, in exsiccato viridescens, costis venis utraque pagine elevatis tenuissimis gracillimis, venis a costa angulo 60° egressis, venulis gracillimis sub luce transversa distincte visis reticulatis, reticulis costalibus mediis triangularibus 5 mm. longis 1½ mm. latis, venis lateralibus mediis 5 mm. a se remotis; pinnis alternis mediis a se (utroque latere) 2½–3 cm. remotis, pinnis inferioribus breviore petiolulatis, mediis superioribus subsessilibus vel sessilibus, pinnis inferioribus a rhachide frondis angulo obtuso, pinnis mediis superioribusque a costa angulo 45° egressis; rhachis frondis dorso complanata plus minus minute squamata medio 1–1½ mm. lata supra sulcata ad medium sulcorum tenuiter costata, costis venis venulis pinnarum utraque tenuiter elevatis, venulis anastomosantibus. Frons fertilis cum ea sterili aequilonga aequilata, pinnis angustissimis linearibus 15 cm. longis 7 mm. latis apice angustissimis basi triangulari-acutis subsessilibus vel breve petiolatis (petiolis 1–2 mm. longis) margine leviter regulariter lobulatis vel repandulis, lobulis 1½ mm. longis 3½ mm. latis apice rotundatis; costa supra elevata, venis supra elevatis a costa angulo recto egressis vermiforme recurvis, venulis reticulatis. Frons per totam paginam densissime sorifera.

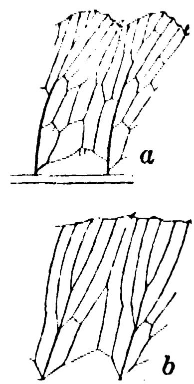


FIG. 33. *Campium angustipinnum* (Hayata) Copeland, comb. nov., *a*, Formosa, *Faurie 281*; *b*, Sikkim, *Jerdon*.

Hab. Prope Hokkokei, leg C. Owatari. Jan. 1898. . . .

Near *Leptochilus virens*, but separable from it by the much longer and narrower pinna.—HAYATA.

As far as it goes, this is the most complete description ever given to *Acrostichum virens* of Synopsis Filicum, which differs from the Formosa plant, if at all, only in the details of the venation. Of Rosenstock's variety, we have a cotype. It is unrelated to either *Campium cuspidatum* or to *Leptochilus cuspidatus* of Christensen, but fits Hayata's description in everything except size. The stipes are 75 centimeters long and 7 millimeters in diameter, and the frond correspondingly large; between this and the figures of Hayata, lies the usual range of "*Acrostichum virens*." The accompanying figures show the venation of Formosan and Sikkim plants.

It has been noted by both Clarke and Beddome that the original sheet of *Acrostichum virens* Wallich is a sheet of blank paper. The original entry of it, Wallich List, page 29, is:

1033 *Acrostichum virens* Wall. Tavoy W. G. (coetera spec. No. 13 &c.)

On page 64 of the List, as a correction, one reads:

1033 Dele Acrost. virens quod est idem ac Taenitis v. Nothol. undulata (140).

The sheet of No. 140 sent me from Kew contains, as an addition, a plant of this species, collected by Griffith, which I thought might be the missing *Acrostichum virens*, the "W. G." of the original entry being the collector's initials; but Griffith's obituary in the Journal of Botany says he did not go to India until 1832.

The *Acrostichum virens* of Synopsis Filicum would have made an interesting herbarium by itself, and in Christensen's Index it gains about as much as it loses. Clearly comprehended in it, and so determined, is a plant collected in Sikkim by Doctor Jerdon, evidently a very large fern, of which I have only the upper 50 centimeters of the sterile frond, with a longer, complete fertile frond. Assam specimens, collected by Gustav Mann, distributed as *Gymnopteris contaminans*, are identical with Jerdon's. Except that there is much less anastomosis of the veinlets, it is indistinguishable from Faurie's Formosa specimen. Having a single specimen of each and no opportunity to study the variability, I am calling them the same. The range of *Campium angustipinnum* thus seems to be from Sikkim to Formosa.

36. CAMPIUM CRISPATULUM (Wallich) Presl. Plate 26.

Campium crispatulum PRESL, Epim. Bot. (1849) 171.

Acrostichum crispatulum WALLICH, List No. 24; CLARKE, Trans. Linn. Soc. Bot. 1 (1880) 580.

Barren pinnæ numerous, often 20 or more, 4 by ½ in., slightly serrate, the midrib often reddish when dry, a series of costal arches without in-

cluded veins along their midribs, no free veins in any of the areolæ; fertile pinnæ 4 by $\frac{1}{6}$–$\frac{1}{8}$ in.—*A. virens*, var., Hook. Sp. Fil. v. 261; Hk. & Baker, Syn. Fil. 420. (Pl. LXXXIV. fig. 2, *b, d.*)

Round Bengal from Kumaon to Bhotan and Chittagong in the lower hills, alt. 0–3000 feet, common.

The only very common Bengal species of the group called *A. virens* by Mr. Baker. Very constant in character, and easily recognized by the absence of free veins.

Var. *contaminans*, Wall. Cat. 22. Barren pinnæ often $\frac{3}{4}$–1 in. broad, more crenated, green or yellowish; fertile pinnæ $\frac{1}{3}$–$\frac{1}{6}$ in. broad. (Pl. LXXXIV. fig. 2, *a, c.*)

Grows with the preceding; a trifling variety.—CLARKE.

This is indeed a very distinct species, characterized by the size, shape, margin, and color of the sterile pinnæ, the terminal quite like the lateral ones, and by the venation. What Clarke meant to say is that there are no *included* free veinlets; the conspicuous feature is the length of the free veins running to the margin. The specific name accurately describes the overfull margin. The color is that of *Campium scalpturatum*, which is distinct enough in other respects.

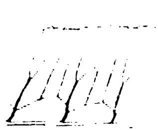


FIG. 34. *Campium crispatulum* Presl; Kamoun, *Wallich* 24.

As to *Acrostichum contaminans* Wallich: The Wallich specimen sent me from Kew is not at all this species, but is *Campium semicordatum*, as Beddome construed it. Using this name, Clarke figured a fern with pinnæ nearly 20 centimeters long, quite different from that to which Beddome applied the name.

37. **CAMPIUM SCALPTURATUM** (Fée) **Copeland, comb. nov.**

Heteroneuron scalpturatum FÉE, Acrost. (1845) 95, pl. 56.

Frondibus sterilibus pinnatis, glabris, frondulis oblongo-lanceolatis, brevissime petiolatis, acuminatis, margine crenato, crenis laceris, incisis, basi cuneatis, mesoneuro nervillisque rubris; frondula terminali longissima, undulata, vivipara; fertilibus pinnatis cum impari, mesoneuro ac nervillis prominentibus, frondulis petiolatis, linearibus, coriaceis, supra duos margines canaliculorum rhachium explicatis, margine undulato, crenato, crenis dentatis, saepe reflexis, basi anguste cuneatis, apice longe acuminatis, petiolulo brevi; rhachi compresso, fasciculos duos vasorum internos includente, inferne subplano, obscure canaliculato superne trisculcato; rhizomate crasso, irregulari, fibris longissimis; sporangiis subrotundis, pedicello lato donatis, annulo 16 articulato, sporis irregularibus, succineis, ovoideis angulatisque.

Habitat in India occidentali, Nepaul, Sylhet (Wallich); Manilla (Gaudichaud, Voy. de la Bonite, 1836).—V. S. in herb. Bory et Mus. Par., ex Gaudichaud.

Sterile fronds 50 to 60 cm. long, on stipes of 15 cm.; their pinnæ about 10 cm. long by 3 wide; fertile fronds reaching a total height of nearly a meter, their longest pinnæ 24 cm. long.

Cyrtogonium costatum? J. Smith, in Journ. Bot. Hook., IV, 1841.

Acrostichum costatum, Wall., herb., no. 26.—*Campium*, Presl, Tentam. Pterid., p. 239?.—FÉE.

Presl [25] scored Fée roundly for the interrogation points quoted above, stating that both he and Smith had consulted specimens labelled by Wallich himself. As I construe these marks, Fée was questioning the identity of *Campium costatum* and his own species. What he described, and knew positively as *Heteroneuron scalpturatum*, was Gaudichaud's plant, from the Philippines, which must accordingly be regarded as the type. It is a rare fern in the Philippines, light green, except as it is tinged with red, sometimes strongly so. I have not seen Wallich's specimens; but if descriptions, and several named specimens from Kew enable me to judge *Campium costatum*, the two are thoroughly distinct. They have in common a tendency to redness, and perhaps for the sporangia to avoid the middle of the pinnæ, but the venation is very distinct, and *C. costatum* has much larger and broader pinnæ.

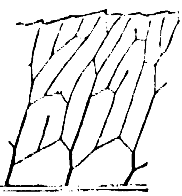


FIG. 35. *Campium scalpturatum* (Fée) Copeland, comb. nov.; Lamao, *Copeland 249*.

It is very much more nearly related to *Campium angustipinnum*, from which it is distinguished by the absence of the latter's many long free veinlets running to the margin, and to *Notholaena undulata* Wallich, as will be noted later. It is the only Philippine representative of the typically Indian group of species. Because of past confusion of species in this group, I do not undertake to state its distribution, if any, beyond the Philippines. A specimen in the Gray Herbarium, apparently from Ceylon, is near to this but hardly identical; it is suggestive also of *Campium semicordatum*. It is probably an undescribed species.

The venation figured is that of a specimen from Lamao, near Manila. Fée's figure is quite exactly duplicated in this respect by *Merrill 7267*, from Palawan. Christensen,[26] following Christ, recognizes a var. *undulatum*, from Koh Chang.

38. **CAMPIUM UNDULATUM** (Wallich: Hooker) Presl. Plate 27.

Campium undulatum (Wallich: Hooker) PRESL, Epim. Bot. (1849) 170.

Notholaena undulata WALLICH, Cat. No. 140, nomen.

Jenkinsia undulata HOOKER, Gen. Fil. (1842) pl. 75 B.

[25] Epimeliae 170.

[26] Bot. Tidsk. 32 (1916) 344.

Sorus linearis, elongatus, continuus, nudus, prope marginem avenium frondis difformis.—Filix tropica, Indica. Frondes pinnatae. dissimiles, foliolis lanceolatis undulato-dentatis coriaceo-membranaceis, saepe proliferis, fertilibus angustioribus, pinnis lato-marginatis. Venae pinnatae, subtus praecipue prominentes, parallelae, strictae. Venulae oppositae, in arcus biangulatos confluentes, venulis secundariis ex angulis arcum liberis apice clavatis, aut in sinum arcus superioris in pinnis fertilibus excurrentibus (marginantibus liberis nudis) in sterilibus omnibus usque ad marginem liberis.

Jenkinsia undulata.—(Tab. LXXV. B.)—HOOKER.

It will be noted that, in form, there is no specific diagnosis, except as the plate and the reference to it may constitute one. The real diagnosis of the species is presented in the diagnosis of the monotypic genus, which identifies the species much better than do the most of the specific diagnoses of a century ago.

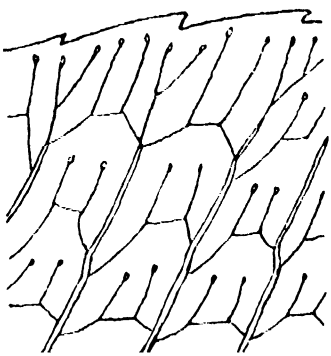


FIG. 36. *Campium undulatum* (Wallich: Hooker) Presl; drawing after Hooker.

It is related to *Campium virens*, confusion with which extends back even to Wallich; see remarks under *Campium angustipinnum*. In spite of Beddome's statement [27] that *Campium deltigerum* and *C. undulatum* "are only abnormal forms . . . . and cannot be recorded as varieties," it should be clear that the restriction of the sporangia to a part of the area can be a valid specific character of some species, and occur as a rare variant in others. The question is one of fact, not of theory. Judging by the Kew material, my belief is that in this instance the restriction of the fructification is the most conspicuous characteristic of a species less conspicuously distinguishable in other respects. A similar restriction of the sporangia is common in *Campium scalpturatum*, which is very distinct in venation and color.

Campium undulatum is known only from the region of its first collection, Martaban.

The accompanying detail of venation is copied from Hooker's plate. My drawing from a Kew specimen has been mislaid; but it is photographed with the Hooker herbarium plant, on Plate 27, and is more than reasonably unlike Hooker's figure.

[27] Ferns of British India and Ceylon 438.

39. CAMPIUM COSTATUM Presl.

Campium costatum (Wallich nomen nudum) PRESL, Tent. Pterid. (1836) 238.

Fasciculi vasorum stipitis in *C.* costato octodecim, duobus primariis anticis oblongo-compressis. Venae in *C.* costato subtus elevatae et costaeformes.—PRESL.

Throughout the history of descriptive or systematic or taxonomic botany, a diagnosis has been whatever would suffice to distinguish the plant in question from any other with which it might be confused. This is and always has been accomplished in major part by the reference of the plant to its genus; and the whole demand on the specific diagnosis has been that it suffice to identify the plant within the genus. This was accomplished by the two statements just quoted. It is granted that Presl was not trying to present a diagnosis; but that was because, in common with the most of his contemporaries, he considered the species already published in valid form in Wallich's list. We may reasonably rule that Wallich's names are nomina nuda, but it is neither reasonable nor seemly for us to be very critical in passing on the sufficiency of anything that can possibly be construed as a diagnosis. It is their common fate to be found inadequate, as more species are discovered or recognized, or as we make finer distinctions between what we are pleased to construe as species. Our own species and diagnoses fare in the same way; and it is to be doubted if even such elaborate and comprehensive disquisitions as Hieronymus published in the place of diagnoses will protect his species against future analysts. By word and by drawing, Presl distinguished *C. costatum* from any other *Campium* known to him; and that was enough.

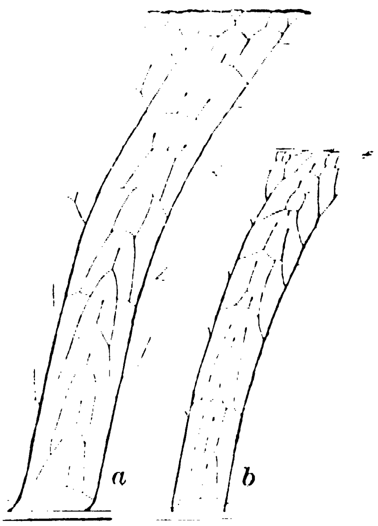


FIG. 37. *Campium costatum* (Wallich) Presl; *a*, from Assam; *b*, from Chittagong.

Barren pinnæ about 11, 8–14 by 2–2¾ in., caudate, stout in texture, drying red, costal arches none or obscure from the presence within them of other veins; secondary areolation copious, with included free veins; fertile pinnæ 6 by ¼–½ in.—Hook. Sp. Fil. v. 262 as to var. α only. *Pœcilopteris costata* Bedd. Ferns Brit. Ind. t. 113.

Round Bengal in the lower hills, alt. 0–3000 feet; from Nepaul to Chittagong, common.

One of the best marked among the Indian *Acrostichums*: its large size, its drying red, its want of costal arches to the midribs of the barren pinnæ, easily distinguish it from all others. It has been joined with *Meniscium deltigerum*, Wall., and with *Acrostichum virens*, Wall., and the descriptions founded on material thus jumbled are not intelligible, but the fern itself is.—C. B. CLARKE, Trans. Linn. Soc. Bot. 1 (1880) 581.

I have quoted Clarke, as one exceptionally familiar with these ferns and at the same time having full herbarium and library facilities for their correct identification. However, on the basis of specimens which he too had in hand, I must correct his observations as to the costal areolæ; these are present, as in all related species, and as shown in the accompanying drawings. Of these drawings, one, from an Assam specimen, shows an almost complete development of median areolæ, showing a clear relation to the venation of *Campium heteroclitum;* the other, from a Chittagong specimen, shows incomplete anastomosis of the veinlets which might form these areolæ, and consequent abundance of free included veinlets, its venation thereby verging toward that of *Campium subcrenatum*, and the species with typical goniopteroid venation. Presl's figure [28] shows the venation of the fertile pinna. I find the free excurrent veinlets more numerous than he shows them, but the difference is not such as to raise any question as to the identity of his fern and Clarke's and mine.

This is the most distinctly coriaceous species in the genus; *Campium subsimplex* may be thicker, but is more fleshy. The frond is opaque with ordinary light, but the venation is remarkably clear and conspicuous when strong light is passed through it. The pinnæ are strongly caudate, commonly with a bud near the base of each tail, or still lower down. The terminal leaflet is like the others but moderately larger, and its bud is more likely to become a plant.

40. CAMPIUM DELTIGERUM (Wallich) Copeland, comb. nov.

Meniscium deltigerum WALLICH, List (1828) No. 59; HOOKER, Spec. Fil. 5 (1864) 262, sub Acr. costato; CLARKE, Trans. Linn. Soc. Bot. 1 (1880) 572.

Small, sori partial generally marginal and interrupted; spots or masses forming transverse lines between the costules frequently having a deltoid form.—HOOKER.

[28] Tentamen pl. 10, fig. 23.

. . . there are no intermediate forms [between this and *Acr. virens*], and the fertile pinnæ are only slightly dimorphous. Col. Beddome's figure [Ferns Brit. India pl. 114] unfortunately does not show the main veins beneath the fertile pinna, which are very strong and a diagnostic mark.—CLARKE.

In size, form, and texture this has fronds and pinnæ much like those of sterile *Campium subcrenatum;* the veins and the veinlets are rather like those of *C. costatum.* Ignoring everything except the fructification, Beddome[29] says, under his *Gymnopteris costata,* that these "are only abnormal forms, such as occur more or less in nearly all the other species of *Gymnopteris* and cannot be recorded as varieties." Leaving fructification out of account for the moment, this differs from *Campium costatum* in having constantly smaller pinnæ with longer stalks, much broader bases, acute but never caudate apices, rarely proliferous even when completely sterile, less even margin, incomparably thinner, and of clear green color. It is only because the fructification is so remarkable that is distracts attention from all of the other differences, that is has been possible to confuse the two species. As to the fructification, such forms are not known in nearly all species of this genus; they are known in a few, and the tendency to form them is a specific character of such species, just as their constant presence is a specific character of this one.

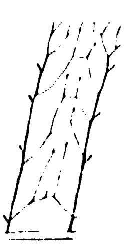


FIG. 38. *Campium deltigerum* (Wallich) Copeland, comb. nov.; Sikkim, *Thomson s. n.*

41. CAMPIUM VIRENS Presl.

Campium virens (Wallich: Hooker and Greville) PRESL, Tent. Pterid. (1836) 239.

Acrostichum virens Wallich: HOOKER and GREVILLE, Icones Fil. 2 (1831) pl. 231.

Frondibus pinnatis (pinnulis subnovem) oblongo-lanceolatis acuminatis membraneceo-coriaceis glabris parallelo-venosis obscure reticulatis cartilagineo-serratis basi oblique cuneatis petiolatis, fertilibus linearibus obtusis, stipite elongato subpaleaceo.

Acrostichum virens. Wall. Cat. . . . No. 1033.

Hab. Tovag in India Orientali (Gul. Govan, M. D.). N. Wallich, M. D.

Caudex oblique repens, crassus, dense paleaceo-squamosus, ...

Stipes pedalis et ultra, semiteres, erectus, sparse squamosus, superne nudus.

Frons late ovata, pinnata; pinnis subnovem, alternis, palmaribus et ultra, oblongo-lanceolatis, membranaceo-coriaceis, glabris, nitidis, pallide

[29] Ferns of British India and Ceylon 438.

virentibus, costatis, pennatim nervosis cum venis anastomosantibus; venulis nonnunquam liberis clavatis; apice attenuatis, marginibus undulatis, paululum incrassatis, remote cartilagineo-serratis, serraturis incurvis, basi oblique cuneatis, in petiolum brevem decurrentibus. *Rachis* glabra, nuda, antice sulcata.

Frons fertilis sterili longior; pinnis brevioribus, linearibus, ad apicem solummodo serratis, obtusis.

. . . In Dr. Wallich's collection is a species much more nearly allied to it (than *A. scandens*); this is the *A. costatum* of the Catalogue, No. 26, but it is twice the size of the present species; the fronds are more coriaceous, the margins more thickened, not waved and crisped, and destitute of serratures. The colour is also very different, being of a purple hue.—HOOKER AND GREVILLE.

Subsequently, Hooker[30] identified this with *Acrostichum subcrenatum;* and Clarke[31] agreed that the two were hardly separable. The superficial resemblance is indeed strong, but the real affinity of *Campium virens* is to *C. costatum* and *C. deltigerum*. The *Acrostichum virens* of Synopsis Filicum is still different (*Campium angustipinnum* of this revision), and some history of *Campium virens*, real and supposed, is given in the discussion of that species. The *Acrostichum virens* of Wallich will probably remain a mystery, but that described and figured by Hooker and Greville is clear beyond any question. If any other species is identical with it, it is *Campium deltigerum;* and the fertile frond is so constant on the several specimens of that species I have seen, that I see no reason to combine them. The fertile pinnæ of plants reasonably referred to *Acrostichum virens* vary from narrowly linear to nearly a centimeter in width, and are all uniformly fructiferous all over the back. The sterile pinnæ are serrate toward the apex; toward the base, they vary from serrate to practically entire.

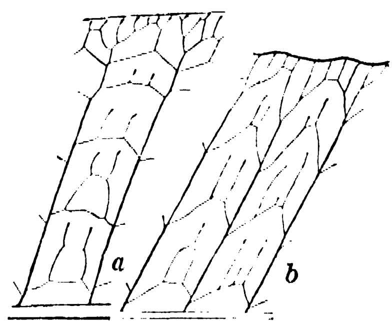


FIG. 39. *Campium virens* (Wallich: Hooker and Greville) Presl; *a*, Sikkim, *J. D. Hooker*; *b*, Siam, *Eryl Smith 1112*.

As stated by Beddome, *Campium virens* is unknown in southern India. It is found in Sikkim, Burma, and Siam (*Eryl Smith 1112*), and Pinang (*Curtis 628*).

[30] Spec. Fil. 5: 261. [31] Trans. Linn. Soc. Bot. 1: 581.

42. CAMPIUM BRADFORDI Copeland, sp. nov. Plate 28.

Campium C. subcrenato affinis, pinnis paucis frondis sterilis oblongis basi rotundatis margine minute serrulatis, foliola apicale haud flagelliforme distincta, aliter speciei designatae similis.

Ceylon, *Bradford*. Type in the herbarium of the University of California, No. 267415.

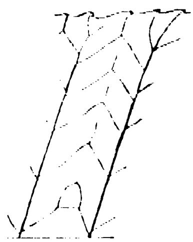


FIG. 40. *Campium bradfordi* Copeland, sp. nov.: type.

In venation, this differs from *C. subcrenatum* only in that, correlated with the rather more ample lamina, the lowest two veinlets are more likely to produce two excurrent veinlets, and these to unit and inclose an areola, but there may be only one excurrent veinlet in *C. bradfordi* or the two may run free; and in *C. subcrenatum*, less commonly, there may be two, and they may unite; or, rarely, there may be even three such veinlets; or, in both species, there may be two excurrent veinlets ("of the second order") from more than one pair of anastomosing veinlets.

43. CAMPIUM MOLLE Copeland, sp. nov. Plate 29.

Rhizomate valido basibusque stipitum paleis fuscis lanceolatis parvis vestitis; stipite frondis fertilis 80 cm alto, gracile sursum glabro, superne trisulcato; pinnis frondis sterilis utroque latere ca. 4, oblongo-lanceolatis, ca. 16 cm longis, 5 cm latis, acutis, basibus late rotundatis, integris, glabris, opacis, brunneis (in herbario), crassis, mollibus, stipitulis brevibus validis; venis primariis utroque facie inconspicuis, venulis more Goniopteridis areolarum seriem unam inter venas conficientibus cum liberis inclusis solitariis longis; foliola terminale paullo majore, crenato-undulata, nec attenuata nec prolifera; fronde fertile ca. 30 cm longa, 10 cm lata, pinnis utroque latere ca. 6, lanceolatis, 6–7 cm longis, 15 mm latis, acutis, basi truncato-cuneatis, dense fructiferis, areolas inter costam et marginem 5–7.

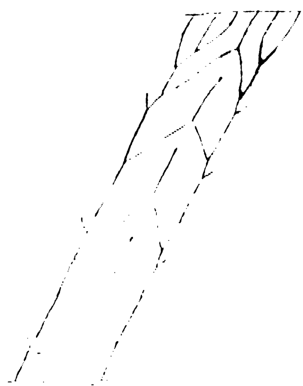


FIG. 41. *Campium molle* Copeland, sp. nov.: type.

Ceylon, *Gardiner*. Type in the Kew Herbarium.

This is the fern referred to by Hooker[32] under *Acrostichum virens* as "probably a distinct species." It differs from both *Campium costatum* and *C. subcrenatum* in texture, color, in-

[32] Spec. Fil. 5: 262.

conspicuous veins, acute but not at all caudate pinnæ, and absence of proliferation, and from the common forms of both, in the broad fertile pinnæ. The number, *1313*, cited by Hooker refers to "Ceylon Plants;" [33] but this is not at all the same as some of the material distributed under that number.

44. CAMPIUM SUBCRENATUM Presl.

Campium subcrenatum (Hooker and Greville) PRESL, Tent. Pterid. (1836) 239.

Acrostichum subcrenatum HOOKER, Hooker and Greville, Icones Fil. (1828) pl. 110.

Frondibus pinnatis, pinnis brevi-petiolatis subcrenatis lanceolatis acuminatis, sterilibus (septenis) basi cuneato-attenuatis, fertilibus (novenis) multo minoribus, basi, inferioribusque apice, obtusiusculis, rachi subalata.

Hab. E. Zeylona, ubi in rupibus, prope Saffragan, provenit, communicavit *D. Emerson, M. D.*—HOOKER.

This was reduced to *Acrostichum virens* by its own author,[34] and Clarke [35] agreed that the two are hardly separable, even as varieties. To this, Beddome [36] made vigorous objection, charging Clarke with "not knowing subcrenata;" but the objection loses its force with Beddome's avowal that he did not himself know *A. virens.* Synonyms are *Poecilopteris terminans* Beddome and *Acrostichum proliferum* Hooker, non Blume, but not *A. contaminans* Wallich, nor *A. terminans* Wallich, nor *A. crispatulum* Wallich. As to the proper specific name, the older authors would have been practically unanimous in sacrificing *subcrenatum* for *virens;* but present usage is equally uniform, in treating Wallich's names as nomina nuda until somebody happened to publish a description or diagnosis with them.

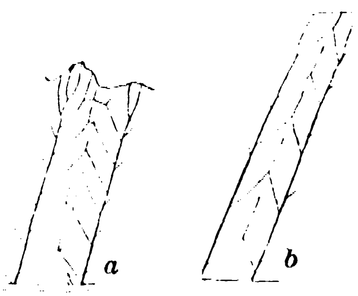


FIG. 42. *Campium subcrenatum* (Hooker and Greville) Presl; *a*, Cochin, *Gamble 14815 cult.*; *b*, southern India, *Gough 61*.

As Beddome has been the more modern protagonist of *Gymnopteris subcrenata*, I quote his description,[37] as follows:

Rhizome thick, fronds glabrous pinnate, 1–4 feet, of which the stipe is sometimes nearly half; stipes and rachis furnished with a few scales;

[33] See Thwaites, Enum. Pl. Zeyl. 380.

[34] Sp. Fil. 5: 261.

[35] Trans. Linn. Soc. Bot. 1: 581.

[36] Ferns of British India and Ceylon 439.

[37] Op. cit. 437.

sterile fronds, pinnæ 4–12 alternate or subopposite petiolate, broad lanceolate, sinuate or waved, with a longish serrated acumination, terminal pinnæ much the longest (sometimes 2 feet long), proliferous at the apex; primary veins close, costate and conspicuous nearly to the margin, veinlets anastomosing pretty regularly at right angles, from which proceed one or two generally free veinlets with clavate apices; fertile fronds conform to sterile, but much contracted.—BEDDOME.

As to the last point, it is to be observed that the fertile fronds of the original *Acrostichum subcrenatum* were not exceedingly contracted; I have here but one specimen, collected in Cochin by Lawson, with fronds as broad as the figure. Also, the original figure does not show an elongate apical leaflet; in most specimens this is as developed as in *Campium heteroclitum.* It is noted with misgivings that the venation of the fertile frond conforms with Presl's figure of *Campium costatum,* very perfectly. The range of venation of the sterile frond is shown in the accompanying drawings.

The sure geographical range is peninsular and northern India.

45. **CAMPIUM FÉEIANUM** Copeland, nom. nov.

Heteroneuron preslianum FÉE, Acrost. (1845) 92, pl. 39, f. 1, as to the description and figure.

Frondibus pinnatis, glabris, frondulis remotis, suboppositis, breve petiolatis, rhachi in parte frondulifera alato; sterilibus acutis, utrinque attenuatis, raro obtusis, subtus punctis atomariis, numerosis conspersis, frondulis superioribus saepe trilobati, infimis aliquando bilobis, lobo superiori brevi obtusissimo; fertilibus longious petiolatis, frondulis omnibus obtusissimis, basi acutis, terminali longiori; rhizomate crasso, repente, squamis angustis, attenuatis lanceolatis; sporangiis amplis, ellipticis, annulo 18 articulato, sporis episporio membraniceo.

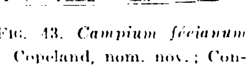


FIG. 43. *Campium féeianum* Copeland, nom. nov.; Concan, *Law s. n.*

Acristichum punctulatum Presl, Rel. Haenk., p. 16, nec Swartzii nec Willd.

Habitat in Philippinis, Sorsogon (Presl), in Asia (Hügel). V. S.

Dimensions: Frondes stériles, 24–30 centim.; le pétiole est égal en longueur à la lame; largeur, 20–22 millim.—Frondes fertiles, 20–25 centim. de largeur; le pétiole est à la lame : : 1: 2; largeur, 7–8 millim.

Cette plante est fort distinct de toutes ses congenères. La nervation présente une maille à sommet anguleux, surmonté d'une droite; elle est formée par la rencontre de deux nervilles latérales. La nervation est donc connivente; elle devrait faire entrer cette plante dans le genre *soromanes*, si tout les autres caractères ne tendaient à en faire un *gymnopteris.* M. Presl, en écrivant *frondibus omnibus fructificantibus,* donne la preuve qu'il n'a connu que la fronde fertile de cette plante.—FÉE.

This is a rare fern of southern India.

SPECIES DUBIAE ORIENTALES

POECILOPTERIS STENOPHYLLA Kurz MS.; Teijsmann and Binnendyk in Nat. Tijdschr. Nederl. Ind. 27 (1864) 15.

P. frondibus pinnatis, pinnis sterilibus membranaceis, alternis, suboppositisve, breviter petiolatis, linearibus, acuminatis, subintegris v. saepius obsolete crenatis, parallelo-venosis, reticulatis, glabris, subtus in costis stipiteque sparse paleatis; fertilibus angustioribus, crenatis, margine revolutis v. rarius planis.

Hab. in montibus prov. Bogor. 3–4000 p. s. m. e. q. in monte Salak.

Caudex repens, ramosus, viridis, brunnescente-paleaceus, radicosus. Frons sterilis, impari-pinnata, stipes ½–¾ ped. longus, obsolete tetragonus, viridis, supra canaliculatus, sparse (in juvenalibus dense-) secedente-paleaceus; pinnae alternae v. rarius suboppositae, lineares v. lineari-lanceolatae, acuminatae, 4–5 poll. longae, 5–8 lin. latae, obsolete crenatae v. subintegrae, supra glabrae, obscure virides, nitentes, subtus in costis paleis brunnescentibus sparsis adspersae; frondis fertilis pinnae lineares v. lineari-lanceolatae, acuminatae, basi in stipitem attenuatae v. oblongo-lanceolatae, obtusae, margine crenato v. subintegro revolutae v. rarius planae, membranaceae, laete virides. Sori creberrimi, nigri, paginam inferiorem dense obtengentes.—TEIJSMANN AND BINNENDYK.

This seems to have been ignored by the Buitenzorg botanists, who should be able to identify the plant. As good a guess as I can make is that it is a nonradicant *Campium heteroclitum.*

CHRYSODIUM SAGENIOIDES Kuhn, Linnæa 36 (1869) 63.

Rhizoma deest; folia membranacea, opaco-viridia, infra in costis et rhachi paleis minutis squamulosa; sterilium lamina 1′ longa, ovata, pinnatisecta, apice pinnatifida; segmenta 7 juga, subsessilia, 7″ longa, 1¼″ lata, elongata, subpinnatifida, apice sinuata; nervi manifesti, primi in latere interno, reliqui catadromi, maculae Sageniae ad sinus loborum 4–5-seriatae, secus costulam 1 seriatae; fertilium lamina 1′ longa, segmenta distantia, petiolulata, ad 2½″ longa, 4‴ lata, e basi latiore elongata, sinuato-pinnatifida, apice integerrima, sorifera.

(*Acrostichum repandum* Hook. Spec. fil. v. p. 260 quoad plant. a Milne ex ins. Aneitens. reportat. t. fragm. aut.)

Aneitium, in silvis montanis (Herus n. 107. Feb. 1860. Milne.).—KUHN.

Much of this description would apply to the fern which I name *Campium samoense;* but it is hardly conceivable that a botanist as attentive to venation as Kuhn would impute the areolæ of *Sagenia* to that species, or any near relative of it. See remarks under *Campium palustre.*

Key to the African species of Campium.

1. Frond simple (or with few pinnæ below a large simple main portion).
   2. Base hastate or decurrent.

3. Free included veinlets wanting.
4. Sterile lamina lanceolate, 3 cm wide .... 54. *C. rawsoni.*
4. Lamina broader and larger .... 53. *C. fluviatile.*
3. Free included veinlets present .... 55. *C. gaboonense.*
2. Base cordate .... (56). *A. phanerodictyum.*
1. Pinnate, apex a leaflet like lateral ones.
2. Pinnæ linear .... 48. *C. salicinum.*
2. Pinnæ broad .... 51. *C. gemmiferum.*
1. Pinnate, apex of 2 to 4 fused pinnæ like others.
2. Pinnæ broadly lanceolate or broader.
3. Gemmiferous near base of terminal leaflet .... 51. *C. gemmiferum.*
3. Not gemmiferous in upper portion .... 52. *C. auriculatum.*
2. Pinnæ linear or linear-lanceolate.
3. Pinnæ entire .... 50. *C. heudelotii.*
3. Pinnæ toothed .... 49. *C. angustifolium.*
1. Pinnate, apex of many reduced pinnæ, or long-attenuate.
2. Sporangia congested on veinlets .... 46. *C. acrostichoides.*
2. Sporangia covering nether surface.
3. Lower pinnæ deeply cut .... 31. *C. bipinnatifidum.*
3. Lower pinnæ entire or nearly so.
4. Free pinnæ less than five .... 32. *C. boivini.*
4. Free pinnæ more numerous .... 47. *C. humblotii.*

46. CAMPIUM ACROSTICHOIDES (Afzelius) Copeland, comb. nov. Plate 30.

Hemionitis acrostichoides Afzelius apud Swartz in Schrad. Journ. (1801) 17.

Frondibus pinnatis distinctis, pinnis lato-lanceolatis, undulato-crenatis apice attenuatis; soris confluentibus. Afzelius.

Sierra Leone Africes.—Quoted from SWARTZ, Syn. Fil. 21.

According to Carruthers,[38] who named this plant *Acrostichum afzelii*, it is the African fern called *Acrostichum virens* in Species Filicum, and I have from the Gray Herbarium a Sierra Leone plant, *Scott Elliot 4048*, so determined at Kew. It is a tall fern, the sterile lamina nearly 60 centimeters long, with many lateral pinnæ and a lobed, lashlike, terminal leaflet. It shares to some extent the characters of the groups of *Campium heteroclitum* and *C. quoyanum*, more nearly related to the former. In venation, it is strikingly like *C. subcordatum*. The sporangia are congested on the veinlets whence its original reference to *Hemionitis*. From the presence of five sheets from Liberia in the United States National Herbarium this seems to be a common species there.

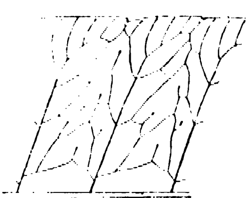


FIG. 44. *Campium acrostichoides* (Afzelius) Copeland, comb. nov.

[38] Cat. Welwitch Plants 2: 277.

47. CAMPIUM HUMBLOTII (Baker) Copeland, comb. nov.

Acrostichum humblotii BAKER, Journ. Bot. 22 (1884) 144.

Rootstock and fertile frond not seen. Sterile lamina oblong-deltoid, simply pinnate, 15–18 in. long, 8–9 in. broad, prolonged into a flagelliform rooting tip, moderately firm in texture, green and naked on both surfaces, the rachis also quite naked. Pinnæ 6 8–jugate, entire, lanceolate, acuminate, 1–1½ in. broad, the upper adnate and decurrent at the base, the lower free but sessile; several lower pairs subequal. Allied to *A. punctulatum* and *Blumeanum*.—BAKER.

Northeastern Madagascar, *Humblot 300*. From the same region, I have had from Kew a specimen collected by J. B. Last, in 1900. The sterile pinnæ are only about five on a side, up to 16 centimeters long, and only 2 centimeters broad, narrowed to both ends, and with the caudate tip denticulate. The more numerous, remote lateral pinnæ of the fertile frond are 4 to 5 centimeters long, about 6 millimeters broad, mostly stipitulate, and obtuse, the terminal one considerably longer.

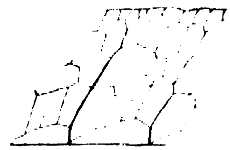


FIG. 45. *Campium humblotii* (Baker) Copeland: Bé Kitus Mountains, northeastern Madagascar, *J. B. Last*, 1900.

It is not very closely allied to *Campium auriculatum* (*punctulatum* of Baker) nor at all to his *Acrostichum blumeanum*, which is a *Lomagramma*. Like *Campium acrostichoides*, it has at least a common parentage with *Campium heteroclitum*. The veins are reddish by transmitted light.

48. CAMPIUM SALICINUM (Hooker) Copeland, comb. nov.

Acrostichum salicinum HOOKER, Spec. Fil. 5 (1864) 265.

Caudex creeping, stipites 4 inches to a span long stramineous (as are the rachis and costae), fronds firm-membranaceous dark-green 3 4 inches to a foot long ovate oblong pinnated to the very apex, pinnae of the *sterile* frond 2 3 10, 1½ 4 inches long rarely exceeding ½ an inch broad lanceolate sometimes long and finely acuminate or obtuse entire or subserrate cuneato-attenuate long-petiolate, costules obscure with few transverse connecting arched veins, these form about two series of large areoles next the costa irregularly anastomosing towards the margin, free included veins rare; *fertile* fronds rather smaller more obtuse and in one instance rather coarsely serrated.

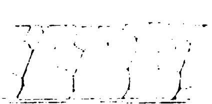


FIG. 46. *Campium salicinum* (Hooker) Copeland, comb. nov.; cotype.

Hab. Niger Exped., Sierra Leone, *Barter*. Fernando Po, *G. Mann*, *n.* 1339.

This very distinct pinnated species has the appearance of having grown in wet places. A sterile frond with alternate, long, narrow-lanceolate, long-petiolate pinnae, with their pale-coloured costae, has very much the appearance of *Salix amygdalina* or some allied species of Osier. Quite different from *A. Heudelotii*, besides other characters, in the entirely pinnated frond, the terminal pinna long-petioled.—HOOKER.

As a mere name, Bonaparte has listed from the Belgian Congo a variety *latipinna*. A sterile cotype in the Gray Herbarium has all pinnæ acuminate, a few of the broadest ones with obliquely crenate margin, and a small bud well below the apex of the terminal leaflet.

Where originally published, the description of this species follows that of *Acrostichum preslianum* (*Campium féeianum* of this presentation); each of these is more nearly related to the other than to any other known species.

49. CAMPIUM ANGUSTIFOLIUM Copeland, sp. nov. Plate 31.

Campium C. heudelotii affinis: rhizomate 5 mm crasso, late repente, paleis atrocastaneis lineari-lanceolatis 4 mm longis persistentibus obtecto; stipitibus remotis, ca. 25 cm longis, fuscis, sursum rhachibusque paleis persparsis praeditis; fronde sterile 30 cm longa, ovata, pinnata; pinnis utroque latere ca. 10, infimis stipitulatis basi subsymmetrice cuneatis, superioribus adnatis, supremis paucis paullo reductis coalescentibus, plerisque ca. 12 cm longis, 1 cm latis, acuminatis, remote et obtuse serratis, herbaceis, opacis, glabris, costa tenue inter venas primarias venulam emittente, venis obliquis, infra marginem dissipatis; areolis primariis paucis, cum venulis inclusis tenuissimis aut liberis et saepe ramosis aut iterum anastomosantibus; fronde fertile conforme paullo minore, pinnis 5–7 cm longis, 6 mm latis, obtusis.

FIG. 47. *Campium angustifolium* Copeland, sp. nov.; type.

Cameroons, Buar, altitude 1,000 m. s. m., on stones in a brook, *Milbraed 9404*. Type in the Kew Herbarium. Also Sanaga, *Zenker 1467*, in the herbarium of the Missouri Botanical Garden, No. 122176.

This differs from *Campium heudelotii* in having narrower and serrate sterile pinnæ and obtuse fertile pinnæ, and apparently in the details of the venation. The apex of the frond is like that of *Campium heudelotii* and unlike that of *C. salicinum*.

50. CAMPIUM HEUDELOTII (Bory) Copeland, comb. nov.

Gymnopteris heudelotii BORY in Fée, Acrost. (1845) 84, pl. 45.

Frondibus pinnatis, glabris, frondulis sterilium lanceolato-linearibus, acuminatis, sessilibus, margine repandis, basi exteriore decurrentibus, ultimis irregulariter connatis pinnatifidisque, petiolis et rhachi canaliculato-striatis, nervillis secundariis et tertiariis rubro-translucentibus, ultimis opacis; fertilibus linearibus, alternis, sessilibus, ultimis pinnatifidis; sporangiis fuscis, magnis, annulo leviter crenato, 13 articulato, sporis ovoideis, episporio caduco,—Planta sicca virescens.

Habitat in aquis vivis Foula Dhiallon in Senegambia (Heudelot).—V. S. in herb. Bory.

Dimensions: Frondes stériles, longueur, 30 centim.; les plus grandes frondules, 20 25 centim.; largeur des lames, 22-25 millim.; des entrenoeuds, mesurés vers les premières paires de frondules, 3 centim. = Frondes fertiles longueur, 34 centim.; les plus longues frondules, 15 centim.; largeur, 1 centim.; distance entre les premières frondules au second entrenoeud, 5 centim.—FÉE.

Probably common in the Congo region; Bonaparte [39] cites nine collections.

The coadunate apex is formed as in *Campium auriculatum*, by the fusion of the bases of a very few pinnæ which are directed almost upward, indicating no affinity to the group of *Campium quoyanum*. The venation is figured by Fée as similar to that shown herewith for *Campium angustifolium*, but apparently with less extreme development of free included veinlets, especially along the costa.

51. CAMPIUM GEMMIFERUM (Hieronymus) Copeland, comb. nov.

Leptochilus gemmifer HIERONYMUS, Engler's Bot. Jahrb. **46** (1911) 345.

L. ex affinitate *L. auriculati* (Lam.) C. Chr.

Rhizoma repens, usque ad 6 mm crassum, juventute dense paleaceum; paleis nigro-fuscescentibus, e basi cordata (auriculis introrsum arcuatis imbricatis) deltoideo-ovatis, acutissimis, margine parce ciliatis (ciliis articulatis saepe apice cellula incrassata glandulosa terminatis vix ultra ½ mm longis), basi cellulis parenchymaticis parte superiore breviter prosenchymaticis parietes internos nigro-fuscescentes c. usque ad 0.015 mm crassos et externos tenues hyalinos vel lutescenti-pellucidos gerentibus numerosis formatis; paleis maximis c. 3¼ mm longis, 1 mm supra basin latis. Folia sterilia c. 3–5 (ex schedula –7½) dm longa, longe petiolata; petiolis supra trisulcatis, infra teretibus, olivaceo- vel griseo-fuscescentibus medio c. usque ad 1⅔ mm crassis, basi crassioribus usque ad 3 mm crassis, praesertim parte inferiore sparse peleaceis (paleis iis rhizomatum similibus, minoribus); laminis pinnatis, infra pinnam imparem terminalem plerumque gemmiferis; pinnis glabris, membranaceis; lateralibus utroque latere 6–10 subsessilibus vel (inferioribus) breviter petiolulatis (petiolulis vix ultra 3 mm longis), e basi superiore rotundato-cuneata et inferiore cuneata sive exciso-cuneata oblongis, acutis vel acuminatis, margine subintegris vel undulato-crenatis vel undulato-lobulatis, plerumque alternis raro (inferioribus) suboppositis; intervallis in laminis maximis usque ad 2½ cm longis; costis utrinque prominentibus teretibus glabris; nervis lateralibus primariis angulo antico c. 60° a costa arcuatim ascendentibus marginem non attingentibus, nervis secundariis vel venis reticulatim anastomosantibus, inter nervos laterales primarios areolarum series 3–4 formantibus, utrinque parum prominulis; pinnis maximis foliorum sterilium maximorum c. 13 cm longis, 2½ cm latis.

[39] Notes Ptérid. 14 (1923) 218, 256.

Folia fertilia longitudine folia sterilia aequantia, interdum paulo longius petiolata, pinnis lateralibus pro conditione minoribus utrinque 5–7 cum impari terminali, obtusiusculis vel acutiusculis. Sporangia superficiem inferiorem ubique obtegentia, c. 0.22 longa, 0.2 mm lata, stipitata (stipite c. 0.4 mm longo). Sporae bilaterales, ubique cristis reticulatim conjunctis c. 0.01 mm altis lutescenti-pellucidis ornatae, fuscescentes, c. 0.5 mm cristis inclusis longae, 0.4 mm latae.

Angola: im Gebiet von Golungo Alto (Welwitsch n. 157b mit dem Manuscriptnamen *Acrostichum* (*Chrysobotrya*) *angolense* Welw.).—HIERONYMUS.

There follow citations of specimens showing the species to be common in German East Africa. Also, description of a var. *latipinnata*, with larger pinnæ, farther apart, with broader base, cited from the Congo and Kamerun.[40] This variety is *Leptochilus acrostichoide* var. *cuneata* R. Bonaparte, Notes Ptérid. **15** (1924) 19.

The species and variety are described as distinguished from *Campium auriculatum* by the usually more numerous, stalked pinnæ, the terminal leaflet not usually fused with the next below, and with a bud at or above the base of the terminal leaflet.

FIG. 48. *Campium gemmiferum* (Hieronymus) Copeland, comb. nov.; Niger, *I. Barter*.

The specimen from which I have drawn the venation was probably collected along the Niger, by Barter (the doubt is due to the mounting of two collections on one sheet), and conforms with the description in all observable characters, including all mentioned as distinctive. There is hardly another instance in the genus of two species so alike in venation as this and *Campium auriculatum*.

52. CAMPIUM AURICULATUM (Lamarck) Copeland, comb. nov.

Acrostichum auriculatum LAMARCK, Encycl. 1 (1783) 36.

Acrostichum punctatum Lin. f. Suppl. 444

Cette plante a ses feuilles aîlées, composées de folioles lancéolées, très-entières, aeterne, glabres & ponctuées en-dessus. Les folioles inférieures sont auriculées, & les supérieures sont confluentes. D'ailleurs, selon M. Linné, cette plante ressemble beaucoup à celle qui précède: on la trouve dans l'île de Bourbon.—LAMARCK.

Acrostichum fronde pinnata: foliolis alternis lanceolatis integerrimis: infimis auriculatis, supremis decurrentibus, supra punctatis glabris.

Habitat in Isle de Bourbon. *Sonnerat per Thouin*.—LINNÆUS f.

[40] A fertile frond of the variety, in the herbarium of the Missouri Botanical Garden, *Zenker 4120*, from Kamerun, has nine or ten pinnæ on each side, mostly about 6 centimeters long by 15 to 20 millimeters wide, the whole frond 45 centimeters long.

Apparently common throughout equatorial Africa, and quite constant in the peculiar form of the frond. The scaly rhizome is creeping, with the fronds rather remote. The upmost two pinnæ, otherwise like the others and but little smaller, are fused at the base; those below them are adnate at least on the lower side; and the basal pair, commonly the only stipitulate ones, bear each a prong on the lower side, as is common in *Tectaria*. Because of this and some minor resemblances to *Pleocnemia*, I was for some time indisposed to transfer the bulk of the African species to *Campium*, suspecting a phylogenetic line related and parallel to *Hemigramma*; but the study of *C. acrostichoides*, especially, has convinced me that while, like the Indian species, they constitute a group coherent within itself, they belong collectively in the same genus as *C. heteroclitum*. A Uganda plant doubtfully referred here, *Drummer 4011*, has very large crenate-sinuate pinnæ.

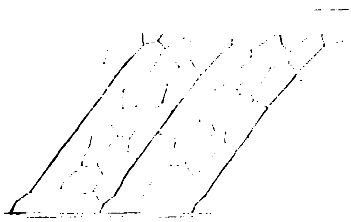


FIG. 49. *Campium auriculatum* (Lamarck) Copeland, comb. nov.: Mauritius.

The specific segregation of *Campium gemmiferum* makes necessary a rechecking of all old specimens, before their respective ranges can be known. Bonaparte[41] cites eighteen collections of *C. auriculatum* and six of *C. gemmiferum*.

53. CAMPIUM FLUVIATILE (Hooker) Copeland, comb. nov. Plate 32.

Acrostichum fluviatile HOOKER, Spec. Fil. 5 (1864) 274.

Caudex long creeping branched, stipites stout a foot or more long, 2 feet of the sterile frond; *sterile* fronds 1½–2 feet long firm-membranaceous simple broad-lanceolate and entire, or larger and hastato-trilobate, with lateral segments 6–7 inches long 2½ inches broad ovato-oblong acuminate horizontal, middle lobe 16 inches long 4 inches wide broad-lanceolate or larger still and pinnatifid with about 5–9 large segments, inferior lateral ones and the terminal one as in the second form just described, costae rather stout, costules indistinct, veins everywhere distinct regularly anastomosing into rather large uniform hexagonal areoles rather smaller towards the margin quite destitute of any free included veinlets; *fertile* fronds similar to the sterile ones hastate or pinnatifid but much smaller.

Hab. Fernando Po, on the banks of a river, *Gustav Mann*, *n.* 442,–Niger Expedition, *Barter*. West tropical Africa, Curror . . . .–HOOKER.

The Fernando Po specimen in the Gray Herbarium, presumably a cotype, has short, merely acute barbs at the base of a large simple frond, the main part of which is acuminate. The

[41] Notes Pterid. 14 (1923) 254.

frond has the deep green color common in species growing in very wet places. The young part of the rhizome is densely covered with long, linear, dark fuscous paleæ, which are also sparsely present on young stipes.

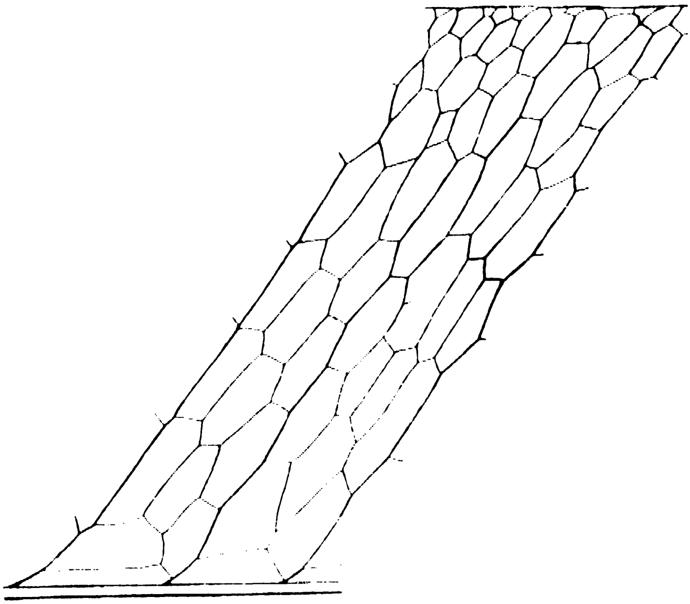


FIG. 50. *Campium fluviatile* (Hooker) Copeland, comb. nov.; cotype with short-hastate frond, Fernando Po.

Such a fern might have been evolved directly from the *Dendroglossa* section; but I think it much more probable that this species is derived, by consolidation of the frond, from pinnate ancestors. A step toward it, in venation as well as in fusion, is represented by *Campium auriculatum*. Specimens from S. Thomé, *Quintas 58*, United States National Herbarium, No. 51084, are a juvenile form of this or a distinct species. The lanceolate, caudate fronds are at most 15 centimeters long, and the stipes are very slender.

54. CAMPIUM RAWSONI (Baker) Copeland, comb. nov.

Acrostichum rawsoni BAKER, Ann. Bot. 5 (1891) 496.

Rootstock erect; basal paleae small, dense, linear, dark brown, crisped. Stipe of sterile frond 6–7 in. long, fragile, naked, pale brown. Sterile frond simple, lanceolate, membranous, glabrous, 6–8 in. long, 1–1¼ in. broad, rounded to a cuneate base. Areolae copious, without free included veinlets. Stipe of fertile frond ½ ft. long; blade linear, 6–7 in. long, ⅙–⅛ in. broad, with enrolled edges. Grand River, Mauritius, *Sir Rawson Rawson*, gathered in 1853. Habit of *A. lanceolatum;* veining different.—BAKER.

55. CAMPIUM GABOONENSE (Hooker) Copeland, comb. nov.

Acrostichum gaboonense HOOKER, Spec. Fil. 5 (1864) 270.

Caudex creeping sparingly paleaceous with dirty-brown small subulate scales, stipites numerous approximate 6–7 inches long sparingly paleaceous at the base, of the fertile fronds twice or thrice as long, fronds simple; *sterile* ones firm-membranaceous 12–14 inches long 3–3½ inches broad ovato-lanceolate acuminate and proliferous at the apex moderately attenuated at the base entire or sinuate at the margin dark blackish-green, costa prominent beneath, venation very distinct, costules horizontal wide apart connected by many transverse curved veins forming a series of long narrow costal areoles free from veins or slightly veinleted, the rest forming several wide arched areoles filled with a network of irregular areoles with or without an included veinlet, veining near the margin free; *fertile* frond 4–6 inches long 1–1½ inch wide lanceolate subentire or sinuato pinnatifid.

Hab. Gaboon River, west tropical Africa, lat. 1° N., *Gustav Mann.*—HOOKER.

Since reported from various places in west tropical Africa, but apparently not very common. It looks like a large relative of *Campium decurrens*, with less abundant free included veinlets. Broad fronds have six or more major areolæ between costa and margin instead of the three or four shown by the accompanying drawing.

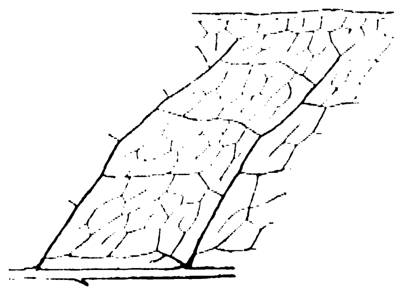


FIG. 51. *Campium gaboonense* (Hooker) Copeland, comb. nov.; *Zenker 3806*.

The specimen in the herbarium of the Missouri Botanical Garden, No. 122190, *Zenker 3806* from Kamerun, has one imperfectly fertile frond, on which the sporangia are borne first on the minor veinlets, and spread to the "parenchyma" only near the margin. The angle at which the main veins leave the costa may be 90°, or may be more acute than as drawn. Kamerun specimens in the United States National Herbarium, *Zenker 3806*, have sterile fronds up to 45 centimeters and the fertile 30 centimeters long.

56. ACROSTICHUM PHANERODICTYUM Baker.

I have been unable to secure a diagnosis of this species or to learn more than that it has long, simple, cordate sterile fronds. It was described from St. Thomas Island, which lies off the west coast of Africa.

In the same group of species, Engler,[42] mentions a *Gymnopteris preusii* Hieronymus, which is reduced by Christensen to his *Leptochilus rivularis;* it seems to be a nomen nudum.

Leptochilus diversifolius and *L. grossedentatus*, named and imperfectly described in French by Bonaparte,[43] are likewise not validated. The former seems to be a small form or relative of *Campium rivulare*, and the latter is multipinnate. The same author[44] lists *Leptochilus currori*, concerning which I know nothing—unless it be that there is a species of *Lonchitis* having that name. Finally, the Index Filicum cites *Acrostichum labrusca* Christ, Ann. Mus. Congo 5 I (1903) 10, but I cannot find it there.

Genus HEMIGRAMMA Christ

The genus *Hemigramma* was established by Christ,[45] for the single species that he called *H. zollingeri*, for the best reason that can motivate the establishment of a new genus for a species long known; namely, the recognition of a source in phylogeny manifestly different from that of the genus from which the species is removed. Christ recognized this species as distinctively tectarid. As I showed soon afterward,[46] this origin is unusually clear, quite as clear as that of *Campium linnaeanum*, shown in the preceding pages. *Hemigramma* is, then:

A genus of tectarid ferns, as shown by the short, stout, erect or ascending, scaly rhizome, scaly stipe, deltoid form of all except simple fronds, and sagenioid venation, distinguished from *Tectaria* by the marked dimorphism and the spread of the naked sori, whether only all along the veins, as in *Hemionitis*, or eventually over the entire neither surface.

A few years after the genus was established, I described a second, apparently well-distinguished, larger species, from Papua. A third, from Mindoro, was resently found for the second time, nearly a century after its discovery; and in looking up the various ferns that are listed as species of *Leptochilus*, I find still others which quite certainly belong here. In every case, this is shown by a combination of the characters of rhizome, stipe, frond form, and venation.

[42] Pflanzenwelt Afrikas 2 (1908) 16.
[43] Notes Ptérid. 14 (1923) 216, 217.
[44] Op. cit. 215.
[45] Philip. Journ. Sci. § C 2 (1907) 170.
[46] Philip. Journ. Sci. § C 3 (1908) 31, pls. 1–4.

Key to the species of Hemigramma.

1. Simple, or pinnate with rachis mostly winged.
   2. Stipe of sterile frond short .... 1. *H. latifolia.*
   2. Stipe 25 cm or more long.
      3. Basal lobes or pinnæ simple.
         4. Fronds trifid .... 2. *H. decurrens.*
         4. Fronds trifoliolate .... 3. *G. bonii.*
      3. Basal pinnæ forked.
         4. Sterile segments or pinnæ lanceolate .... 4. *H. hollrungii.*
         4. Sterile divisions broader .... 5. *H. taccifolia.*
1. Pinnate, rachis mostly wingless.
   2. Apical segment trifid .... 6. *H. grandifolia.*
   2. Apical segment simple .... 7. *H. siifolia.*

1. HEMIGRAMMA LATIFOLIA Copeland.

Hemigramma latifolia (Meyen: Goldmann) COPELAND, Philip. Journ. Sci. § C 2 (1907) 406.

Polybotrya latifolia Meyen in herb., teste Presl.

Gymnopteris latifolia PRESL, Tent. Pterid. 244, nomen; GOLDMANN, Nova Acta 19 Suppl. 1 (1843) 460.

Frondis simplicis pinnis coriaceis oblongis margine irregulariter crenatis acuminatis uno latere basis decurrentibus, venis subpinnatis, venulis binis primariis cum venis trapezoideas aut hexagonoideas figuras formantibus, venulis secundariis, tertiariisque in diverse formae figuras concurrentibus et in apice globoso desinentibus, pinnis fertilibus contractis, soris paginam inferiorem totam tegentibus. Manila.—GOLDMANN.

Presl's[47] much better description fixes the type locality definitely at "Hali-Hali," properly Jalajala, Rizal Province, Luzon.

This may well be the least stable of all the species of ferns. It has the distinction of appearing in Christensen's Index under two widely separated genera, and has been referred by various authors to a long list of others. This is due to variability in the distribution of the sporangia, and it owes a wealth of specific names to its variability in other respects.

The rhizome is more or less erect, short, stout, densely covered by scales, roots, and bases of stipes; the stipes are likewise quite densely and persistently scaly. The commonest form has very short stipes, from a few millimeters to 2 or 3 centimeters in length, the fronds forming a dense rosette. With simple, entire fronds, it is typical *Polybotrya latifolia* Meyen, *Hemionitis zollingeri* Kurz, and *Leptochilus hilocarpus* Fée. Such fronds may be less than 10 centimeters long on plants already in fruit. Somewhat larger plants, with a large lobe on (one

[47] Epimeliae 150.

or) both sides at the base, are *Gymnopteris trilobata* J. Smith: Mettenius. With still larger fronds, commonly 15 to 25 centimeters long, and two or three pairs of lobes, it is *Gymnopteris subquinquefida* J. Smith, *Leptochilus*, Fée; and there is nothing in the description of *Leptochilus trifidus* v. A. v. Rosenburgh, Bull. Dept. Agr. Ind. Nierl. 18 (1908) 26, to create the suspicion that it is at all different. These forms are not merely connected by intermediates; they very generally occur together, and, once a plant outgrows the exclusively simple stage, it usually bears a variety of fronds, different enough to characterize good species if they were constant. Nor does this exhaust the forms; it is not at all rare for the basal lobes to become separate pinnæ. It is rare, but does occur, that these basal pinnæ are forked at the base on the lower side. Plants with large fronds usually bear fewer of them, and the rosette character disappears. The base of the frond may be decurrent, or acute, or abrupt, or cordate, or be abruptly contracted to a short, broad wing, itself abrupt at the bottom.

The fertile frond is longer-stalked, as is practically universal among ferns with dimorphous fronds. It may conform in division with the sterile fronds of the same plant, or may be more nearly simple. It is usually narrowly linear, but not filiform; dilated fronds, which I construe as atavastic, are not rare. The sporangia are at first confined to the veins, but may finally extend to the parenchyma.

It may be observed that I retain *Campium minus* with the status of a species, but do not similarly distinguish the dwarf forms of *Hemigramma latifolia*, likewise fertile, and often collected by themselves. This is done on the basis of field familiarity with both in the Philippines. Only cultural study will finally determine which course is proper in either case.

Common in the Philippines; known in various other parts of Malaya.

2. HEMIGRAMMA DECURRENS (Hooker) Copeland, comb. nov.

Gymnopteris decurrens HOOKER, Journ. Bot. 9 (1857) 359; Exotic Ferns, pl. 94.

Gymnopteris harlandi HOOKER, Garden Ferns, pl. 6; *Leptochilus harlandi* C. Christensen.

Fronde sterili ampla submembranacea nitida pinnata, pinnis subquinque ovali-lanceolatis longe tenui-acuminatis obscure sinuatis basi decurrentibus tribus superioribus coadunatis terminali maxima, fertilimulto minore rigidiore, pinnis angustioribus vix acuminatis repando-sinuatis, stipite elongato rachibusque castaneis nitidissimis.

Hab. Hongkong, *Dr. Harland*.—HOOKER, Journ. Bot. 9 (1857) 359.

This seems to be larger than any other species of its genus; sterile frond 45 centimeters long, beside a tall stipe, and 35 centimeters wide. As in other species, the rhizome is stout and the fronds are crowded. See further comment under *Gymnopteris bonii*, infra.

3. GYMNOPTERIS BONII Christ.

Gymnopteris bonii CHRIST, Bull. Herb. Boiss. II 4 (1904) 610.

Magna. Rhizomate brevi obliquo ascendente digiti crassitie, lignoso. Stipitibus subfasciculatis (3 vel 4). Stipite tenui ad basin incrassato rufobrunneo, squamis nitidis subulatis 1 cm. longis dense vestito. Folii sterilis stipite 25 cm. longo, folii fertilis stipite 40 ad 45 cm. longo.

Fronde sterili deltoideo-pinnata 25 ad 30 cm. longa 20 cm. lata, pinna terminali ampla triloba (interdum biloba aut integra) ovato-acuminata 20 ad 25 cm. longa, lobo terminali 15 cm. longo 8 cm. lato cum lobis lateralibus aliquantum minoribus ad basin late, saepe oblique connato decurrenti, a pinnis lateralibus spatio 5 cm. metiente separato. Pinnis duabus lateralibus paribus (una utroque racheos latere), ovatis, rarius decurrentibus. Pinnis et lobis integris aut leviter undulatis. Costis rufescentibus. Nervis lateralibus fere usque ad marginem conspicuis, 7 mm. inter sese distantibus, areolis magnis nervulis multis ramosis liberis clavatis repletis.

Fronde fertili conformi, sed valde reducta, 10 cm. longa, lobis pinnisque 7 cm. longis 1 cm. latis lanceolato-linearibus acutis crenato-repandis, facie inferiori sporangiis confertis brunneis omnino repleta, vix costa emergente.

Textura herbacea, facie glabra, colore brunneo-viridi. Ad *G. Harlandi* (Hook. Acrostich.) Chinae meridionalis (Hong-Kong C. Faber) accedens, quae multo minor, valde coriacea.

Hab. Tonkin Gall. Ninh-Thoi C. P. Bon, 22. XII. 1888, N° 4070, 5410. Formosa in rupestribus littoris Kelung C. Faurie, mai. 612.—CHRIST.

There is no question that this belongs in *Hemigramma*, and in most genera it would hardly occur to me to doubt its specific distinctness. In *Hemigramma*, I have enough doubt not to care to transfer the name. I have from the Gray Herbarium a specimen of *Hemigramma decurrens* from Formosa, collector and date not stated, but distributed from Kew. It is moderately, but not "valde," coriaceous and, unlike the Hong Kong plant as described (in English) and figured, has the ribs of the sterile frond absolutely glabrous beneath. In form and stature it conforms perfectly to Hooker's specifications.

Leptochilus kanashiroi Hayata, Icones Fl. Form. 5 (1915) 298, is described as distinguishable from *L. bonii* "by the much broader pinnæ of the fertile fronds." The frond may be trifoliolate or merely trifid, and the segment may be entire or irregularly crenate-lobed. Such differences are far within the range of forms familiar in *H. latifolius*, and might be expected in its relatives. A Kuangtung specimen, *Levine 748*, has the

fertile pinnæ nearly as wide as Hayata describes, and simple and trifoliolate fronds on the same plant. The rhizome and the scales on it and on the bases of the otherwise naked stipes are characteristic of the genus. It is papyraceous, not coriaceous.

4. **HEMIGRAMMA HOLLRUNGII (Kuhn) Copeland, comb. nov.**

Gymnopteris hollrungii KUHN, in Schumann and Hollrung, Fl. Kaiser-Wilhelmsland (1889) 8.

I have not seen the original diagnosis of this, but quote from van Alderwerelt, Malayan Ferns, page 737:

Rhizome erect, densely clothed with ferrugineous, long-acuminate bristle-like scales. Stipes scaly at the base, 40–50 cm. long, canaliculate. Sterile fronds 25–30 cm. long, 35–40 cm. broad, with the base pedatisect, the higher part pinnatifid; lobes lanceolate, 25–30 cm. long, 3–4 cm. broad, entire, acuminate. Texture subcoriaceous, surfaces naked. Fertile fronds 25–30 cm. long, 30–40 cm. broad, pinnatifid, on stipes 60–65 cm. long; lobes 15–20 cm. long, linear, entire or slightly sinuato-repand.

New Guinea and New Pomerania.

5. **HEMIGRAMMA TACCIFOLIA (J. Smith: Fée) Copeland, comb. nov.**

Gymnopteris taccaefolia J. SMITH, Hooker's Journ. Bot. 3 (1841) 403, nomen.

Leptochilus taccifolius FÉE, Acrost. (1845) 89, pl. 50.

Frondibus sterilibus amplis, pinnatifidis, segmentis infimis bipartitis, lateralibus ovato-lanceolatis, acuminatis, glabris, repandis, inferne subpetiolatis, superne basi confluentibus, rhachi alato, impari tripartita, nervillis prominentibus, reticulato-flexuosis, rufescentibus; fertilibus pinnatifidis, anguste linearibus, oppositis, segmentis infimis bifidis, apice acuminatis, stipitibus in omnibus glabris, striatis, depressis; rhizomate crasso; sporangiis annulo lato, 11–12 articulato, sporis ovoideis, episporio inaequale membranaceo.

Dimensions: Longueur de la fronde stérile, 43 centim.; pétiole, 7 centim.; frondules de la base, 22 centim., sur 5–6 de large; elles ouvrent avec la nervure médiane un angle de 65° environ. Longueur de la fronde fertile, 42 cent.; partie fructifère, 18 centim.; segments inférieurs, 12–14 centim.—FÉE.

MINDORO, *Cuming 357*, Puerto Galera, Bur. Sci. *46428 Ramos*, 1925.

From the Cuming collection, Presl, too, described this fully as to the laminæ, but without trying to state the length of the stipe of the sterile frond. As to the Ramos collection:

Stipe of the sterile frond 20 to 35 centimeters long, of the fertile frond, up to 50 centimeters. Sterile frond 25 to 35 centimeters long, and not quite as wide, pinnate, or sometimes with the rachis winged to the base. Free pinnæ usually one pair,

opposite, adnate or not, deeply cleft near the base on the lower side; above these, about three pairs of oblanceolate, acuminate lobes of which the lower are sometimes free (pinnæ), and a larger apical segment. Fertile frond about as large, its pinnæ up to 25 or 30 centimeters long, one or two pairs of them deeply split into two long, linear or filiform divisions. Following Hooker, and well knowing *Hemigramma latifolia* to be extremely variable, I supposed this to be merely its most ample form. Having this idea, when the real *H. taccifolia* came recently into my hands, I prepared for it a diagnosis as a new species; however, it is very exactly, and completely enough, described by Presl. At least as to the specimens in hand, it differs from *Hemigramma latifolia* in color, being a light, brownish green, whereas the latter is characteristically either quite dark, or mre often mottled.

6. HEMIGRAMMA GRANDIFOLIA Copeland.

Hemigramma grandifolia COPELAND, Philip. Journ. Sci. § C 6 (1911) 77.

Fronde pinnata ca. 30 cm alta et lata, longe stipitata; pinnis oppositis utroque latere 2 vel 3; pinnis sterilibus vel segmentis earum obloneeolatis, acuminatis; infimis 1 vel 2 furcatis, apicale trifida, frondis fertilis pinnis infimis usque ad 15 cm longis, 2 mm latis, simplicibus, sporangiis laminam obtegentibus.

No. 328, Lakekamu.

A very distinct species, the sterile frond preserving in large measure the form of *Tectaria crenata*, from which, or from near which I consider the genus to be descended.—COPELAND.

Known only in New Guinea and only from the one collection.

7. HEMIGRAMMA SIIFOLIA (Rosenstock) Copeland, comb. nov.

Leptochilus siifolius ROSENSTOCK, Med. Rijks Herb. Leiden 14 (1912) 32.

Adest folium unicum sterile et unicum fertile.—Folium sterile (stipite incl.) 32 cm longum, 27 cm latum; stipes 2 mm fere crassus, ochraceo-stramineus, basi fuscescenti paleis parvis, lanceolatis, fuscis sparse ornatus, sursum cum rhachi brevissime tomentosus; lamina e basi cordato-truncata rotundato-deltoidea, membranaceo-herbacea, in sicco lutescenti-viridis, costis supra brevissime tomentosis exceptis glaberrima, pinnata; pinnae oppositae, trijugae cum impari terminali, obovato-oblongae, breviter acuminatae, margine integerrimae, basales recte patentes, profunde furcatae, ramo posteriore quam anterior paulo minore, ceterae suberectae simplices, inferiores et mediales breviter petiolatae, superiores subsessiles, terminalis petiolo 1 cm fere longo instructa; pinnae omnes inter se fere subaequales, terminalis maxima, 16 cm longa, 3½ cm lata; costae subtus prominentes, supra prominulae; venae primariae conspicuae, strictae, sub angulo 60° ex costa excurrentes, marginem fere attingentes, secundariae et tertiariae

more *Sageniarum* dense reticulatae, maculis venis liberis creberimis instructis; folium fertile stipite 35 cm. longo instructum, lamina sterili subaequalis et ambitu conformis, attamen pinnae anguste lineares et circinnato-flexuosae.

Lombok SW., Sepi-berg, Nordabhang, 0–300 m. (C. Gründler no. 2485).

Diese Art unterscheidet sich von dem nächst verwandten *Leptochilus latifolius* Meyen von den Philippinen besonders durch die Gestalt der sterilen Blätter. Während diese bei genannten Art entweder durchaus oder doch in ihrem oberen Theil fiederschnittig sind, besitzt unsre Art echt gefiederte Blätter mit gestielten und nicht herablaufenden Fiedern. Sie gleichen denen des *Aspidium siifolium* Willd., sowohl in der gestalt, als auch in der Nervatur.—ROSENSTOCK.

Excepting of *Hemigramma latifolia*, past collections are not sufficient for the satisfactory characterization or delimitation of the species of *Hemigramma*. I do not try to decide that seven species, or only seven valid species, are known to date. *Hemigramma latifolia* is quite certainly distinct from any other species listed here; and its listed synonyms are positively such, with the possible exception of *H. zollingeri*. As to the latter, while nothing of the kind can be deduced from its description, better acquaintance may show that it is locally evolved, independently of the simple form of *H. latifolia*.

Hemigramma decurrens, *Gymnopteris bonii*, and *Leptochilus kanashiroi* are not well enough known to establish their constant differences, or their identity. Plants conforming to their respective descriptions have concurrent distribution, and there has not been sufficient collection to demonstrate that any one of them is constant, or variable, in character. It should be emphasized that the fact that *H. latifolia* is exceedingly variable is no conclusive argument against the constancy of a related species. *H. taccifolia* appears to be local and clear-cut.

These remarks as to the far-northern species apply equally to the three large species of the southern area, *H. hollrungii*, *H. grandifolia*, and *H. siifolia*. If they conform to the published descriptions, they are distinct; but single collections provide inadequate evidence that they do this.

Genus QUERCIFILIX Copeland, novum

Genus tantum monotypicum filicum verosimiliter e Sagenia evolutarum; rhizomate ad terram repente; frondibus parvis approximatis, pinnatis, dimorphis, pilosis; venulis anastomosantibus cum liberis ramosis inclusis; sporangiis primo ad venas frondium valde contractarum restrictis laminam deinde obtegentibus.

Species unica cognita:

QUERCIFILIX ZEYLANICA (Houttuyn) Copeland, comb. nov.

Ophioglossum zeylanicum HOUTTUYN, Nat. Hist. 14 (1783) 43, pl. 43, fig. 1; CHRISTENSEN, Index Fil. (1906) 472.

Rhizome rather slender, creeping, scaly. Stipes approximate, short, 2 to 4 cm long, sparsely scaly at the base and pubescent throughout. Sterile frond 6 to 10 cm long, 3 to 5 cm wide, normally with one pair of sessile basal pinnæ, which are always dilated at their base, and usually large enough to make this decidedly the widest part of the frond. Above these, the body of the frond is pinnately lobed with roundish lobes, and the apex is rounded. A main vein enters each lobe, but does not reach its apex; otherwise, except in basal pinnæ which themselves are lobed, there are no main veins. The venation is rather irregular, perhaps in correlation with the small size; free included veinlets are fairly numerous, but without any regularity. Fertile frond of the same design, but small and long-stalked, its divisions only 2 to 3 mm wide, the basal ones often forked.

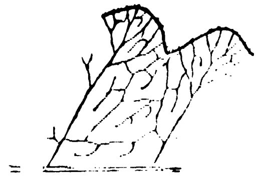


FIG. 52. *Quercifilix zeylanica* (Houttuyn) Copeland, comb. nov.; Hong Kong.

This fern has been called *Ophioglossum, Osmunda, Acrostichum, Onoclea, Gymnopteris, Leptochilus, Dendroglossa,* and *Polybotrya.* It is in all herbaria, and in cultivation, and has been figured repeatedly. *Acrostichum* and *Gymnopteris* were reasonable names in their time; but it has had no generic name that it can keep when a genus is construed as a group composed of species related, instead of merely similar. If it had to be placed in any one of to-day's genera, this would most conveniently be *Hemigramma,* and most properly be *Tectaria.* I do not believe that any descendant of the Polypodieæ inherits the possibility of producing such hairs as clothe its stipe, nether surface and margin. Fée tried to establish a genus *Dendroglossa,* composed of this species and *Hemigramma,* but this was not the *Dendroglossa* of Presl, which is indisputably polypodiid in origin. I believe *Quercifilix* to be tectarid, but not, within *Tectaria,* of common origin with *Hemigramma.* The source of the latter is clearly in the affinity of *T. decurrens.* The probable source of *Quercifilix* is in the quite distinct group represented, for example, by *Tectaria labrusca.*

The wide dissemination of *Quercifilix*—Mauritius and Ceylon to Formosa and Borneo—and its uniformity wherever it has

been found, indicate a very considerable age. It does not remain in such a plastic condition as does *Hemigramma latifolia*.

SPECIES EXCLUDENDAE

LEPTOCHILUS (CHRYSODIUM) RAAPII v. A v. Rosenburgh, Bull. Dept. Agr. Ind. Néerl. 18 (1908) 27, pl. 8.

This is a true *Acrostichum*, as shown by the shape, texture, and venation of the pinnæ, erect caudex, and densely clustered stipes, and most definitely by the narrow, dark paleæ with lighter-brown margins. It is to be suspected of being juvenile *Acrostichum aureum*.

DRYOPTERIS CELEBICA (Baker) Copeland, comb. nov.

Acrostichum celebicum BAKER, Kew Bull. (1901) 145.
Leptochilus celebicus C. CHRISTENSEN, Index Fil. (1905) 384.

Baker's citations of specimens are: *Curtis 431* and *Sauvinière 61*, of which I have Sauvinière's from Kew. Neither stipe nor rachis is really naked, and the pinnæ are mostly coarsely serate, rather than "leviter pinnatifidis" with obtuse lobes. However, in the absence of opportunity to compare the two collections, I accept Baker's judgment of their identity, and keep his specific name for Sauvinière's plant. It is clearly a member of the *Dryopteris canescens* group, very rich in species as well as in names, in Celebes and the Philippines. It is near to, but not identical with, *Aspidium canescens* forma *acrostichoides* Christ, Ann. Jard. Bot. Buit. 15 (1898) 132, which may be identical with the same author's var. *acrostichoides*, Philip. Journ. Sci. § C 2 (1907) 200, of his "new subspecies," *D. diversiloba* (Presl). It is likewise nearly related to *Dryopteris hosei* (Baker) C. Christensen.

For the correct assignment of the following four species, I am indebted to Dr. Carl Christensen. None of them seemed to fit well in any genus ever included in *Leptochilus*, but their correct placing was not possible from the published descriptions alone. Knowing that Doctor Christensen was engaged with the ferns of Borneo, and in possession of the necessary authentic specimens from Kew, I asked his help, and he has very kindly advised me as follows:

ACROSTICHUM EXSCULPTUM Baker, Journ. Bot. 26 (1888) 326.

"Is to the smallest details identical with *Meniscium stenophyllum* Baker (*Dryopteris brevipinna* C. Chr.), now **Dryopteris exsculpta** (Baker) C. Chr."

ACROSTICHUM ANTROPHYOIDES Baker, Journ. Linn. Soc. Bot. 22 (1886) 231.

"This is *Loxogramme iridifolia* (Christ) Copel., now **Loxogramme antrophyoides** (Baker) C. Chr."

This is well known in Borneo, as well as in Celebes and the Philippines, under Christ's specific name. The parties to the nomenclatorial history of this species make it particularly pertinent to recall here Christ's review of Christensen's Index, in which Christ berated the changer of names, and maintained that the real service to botany was performed by the man who recognized and described a new species, and that there is material injustice in making his name subordinate to that of one who merely changes the generic name. With full reverence for Doctor Christ, who would have required a revelation to know that he was redescribing Baker's species, I think it is clear here that the real service is neither Christ's nor Baker's, but Christensen's.

ACROSTICHUM MODESTUM Baker, Journ. Linn. Soc. Bot. 22 (1886) 231.

"According to a sterile specimen in herb. Christ from the type collection, identical with a fertile specimen from the Sarawak Museum, this is technically a simple-fronded *Tectaria*, in habit resembling *Diplazium lanceum*."

ACROSTICHUM OLIGODICTYON Baker, Journ. Linn. Soc. Bot. 24 (1887) 261.

"This is a member of the meniscioid group of *Dryopteris*, closely related to *D. exsculpta*, *D. hosei*, *D. firmula*, and others, and is **Dryopteris oligodictya** (Baker) C. Chr."

ILLUSTRATIONS

PLATE 1

Leptochilus axillaris (Cavanilles) Kaulfuss; *a*, abnormal, partly fertile fronds; *b*, branch showing axillary buds.

PLATE 2

Leptochilus platyphyllus Copeland, sp. nov.; type.

PLATE 3

Campium linnaeanum (Fée) Copeland, comb. nov.; *a*, atavistic form; *b*, typical form.

PLATE 4

FIG. 1. *Campium minus* (Fée) Copeland, comb. nov.; *Cuming 326*, in herbarium Copeland.
2. *Campium dilatatum* Copeland, sp. nov.; type.

PLATE 5

FIG. 1. *Campium laciniatum* Copeland, sp. nov. (?), simple form.
2. *Campium lanceolatum* (Fée) Copeland, comb. nov.; small specimen, from Concan.

PLATE 6

Campium ovatum Copeland, comb. nov.; type.

PLATE 7

Campium laciniatum Copeland, sp. nov.; type.

PLATE 8

Campium subsimplex (Fée) Copeland, comb. nov.; imperfectly pinnate form.

PLATE 9

Campium hydrophyllum Copeland, comb. nov.; type.

PLATE 10

Campium nigrum Copeland, sp. nov.; type.

PLATE 11

Campium pseudoscalpturatum Copeland, sp. nov.; type.

PLATE 12

Campium foxworthyi Copeland, sp. nov.; type.

PLATE 13

Campium tenuissimum Copeland, sp. nov.; type.

PLATE 14

Campium cuspidatum (Presl) Copeland, comb. nov.; *Cuming 161.*

PLATE 15

Campium validum Copeland, sp. nov.; type.

PLATE 16

Campium subcordatum Copeland, sp. nov.; type.

PLATE 17

Campium interlineatum Copeland, sp. nov.; type.

PLATE 18

Campium palustre (Brackenridge) Copeland, comb. nov.; type.

PLATE 19

Campium samoense Copeland, sp. nov.; type.

PLATE 20

Campium rivulare (Brackenridge) Copeland, comb. nov.; type.

PLATE 21

Campium parvum Copeland, sp. nov.; type.

PLATE 22

Campium argutum (Fée) Copeland, comb. nov.; large form, *McLean et al. s. n.*

PLATE 23

Campium semicordatum (Baker) Copeland, comb. nov.; cotype on the right.

PLATE 24

Capium semicordatum (Baker) Copeland, comb. nov.; collected by Beddome.

PLATE 25

Campium lanceum Copeland, sp. nov.; type.

PLATE 26

Campium crispatulum (Wallich) Presl; Wallich specimen in the Kew Herbarium.

PLATE 27

Campium undulatum (Wallich: Hooker) Presl; type.

PLATE 28

Campium bradfordi Copeland, sp. nov.; type.

PLATE 29

Campium molle Copeland, sp. nov.; type.

PLATE 30

Campium acrostichoides (Afzelius) Copeland, comb. nov.; Sierra Leone, *Scott Elliott 4048.*

PLATE 31

Campium angustifolium Copeland, sp. nov.; type.

PLATE 32

Campium fluviatile (Hooker) Copeland, comb. nov.; cotype.

TEXT FIGURES

[Text figures were drawn five times natural size and reduced to twice natural size, except fig. 36, which is a copy of Hooker's figure.]

FIG. 1. *Campium linnaeanum* (Fée) Copeland, comb. nov.; Davao.

2. *Campium minus* (Fée) Copeland, comb. nov.; a normal leaf from Los Baños, Laguna. Free included veinlets are usually much more numerous.

3. *Campium minutulum* (Fée) Copeland, comb. nov.; Khasia, *Hooker and Thomson.*

4. *Campium dilatatum* Copeland, sp. nov.; type.

5. *Campium metallicum* (Beddome) Copeland, comb. nov.

6. *Campium lanceolatum* (Fée) Copeland, comb. nov.; peninsular India.

7. *Campium decurrens* (Blume) Copeland, comb. nov.; Java, *Winckel 1335B.*

8. *Campium zeylanicum* (Fée) Copeland, comb. nov.

9. *Campium ovatum* Copeland, comb. nov.; type. Frond simple.

10. *Campium laciniatum* Copeland, sp. nov.; type.

11. *Campium subsimplex* (Fée) Copeland, comb. nov.; *Bolster 244.*

12. *Campium hydrophyllum* Copeland, comb. nov.; type. Frond simple.

13. *Campium heteroclitum* (Presl) Copeland, comb. nov.; *Cuming 5.*

14. *Campium nigrum* Copeland, sp. nov.; type.

15. *Campium diversifolium* (Blume) Copeland, comb. nov.; Java, *Palmer and Bryant 555.*

16. *Campium pseudoscalpturatum* Copeland, sp. nov.; type.

17. *Campium foxworthyi* Copeland, sp. nov.; type.

18. *Campium tenuissimum* Copeland, sp. nov.; type.

19. *Campium cuspidatum* (Presl) Copeland, comb. nov.; *a*, from *Cuming 161*; *b*, from cotype of *Gymnopteris inconstans* Copeland.

20. *Campium quoyanum* (Gaudichaud) Copeland, comb. nov.; *a*, Mindanao, *Elmer 13458'*; *b*, *Acrostichum repandum* Blume, Java, *Mousset 140*; *c*, *Campium quoyanum*, China, United States National Herbarium, No. 232248; *d*, near *Campium quoyanum*, Todaya, Mindanao, *Copeland s. n.*

21. *Heteroneuron sinuosum* Fée; cotype.

22. *Campium validum* Copeland, sp. nov.; type.

23. *Campium subcordatum* Copeland, sp. nov.; *a*, type; *b*, cotype.

24. *Campium interlineatum* Copeland, sp. nov.; type.

25. *Campium palustre* (Brackenridge) Copeland, comb. nov.; Tahiti, *Setchell and Parks 485.*

26. *Campium samoense* Copeland, sp. nov.; type.

27. *Campium rivulare* (Brackenridge) Copeland, comb. nov.; Fiji, *Horne 694.*

28. *Campium parvum* Copeland, sp. nov.; type.

FIG. 29. *Campium argutum* (Fée) Copeland, comb. nov.

30. *Campium bipinnatifidum* (Mettenius) Copeland, comb. nov.; Seychelles.
31. *Campium semicordatum* (Moore: Baker) Copeland, comb. nov.; *a*, cotype; *b*, India, *Beddome*.
32. *Campium lanceum* Copeland, sp. nov.; type.
33. *Campium angustipinnum* (Hayata) Copeland, comb. nov.; *a*, Formosa, *Faurie 281*; *b*, Sikkim, *Jerdon*.
34. *Campium crispatulum* Presl; Kamoun, *Wallich 24*.
35. *Campium sculpturatum* (Fée) Copeland, comb. nov.; Lamao, *Copeland 249*.
36. *Campium undulatum* (Wallich: Hooker) Presl; drawing after Hooker.
37. *Campium costatum* (Wallich) Presl; *a*, from Assam; *b*, from Chittagong.
38. *Campium delligerum* (Wallich) Copeland, comb. nov.; Sikkim, *Thomson s. n.*
39. *Campium virens* (Wallich: Hooker and Greville) Presl; *a*, Sikkim, *J. D. Hooker*; *b*, Siam, *Eryl Smith 1112*.
40. *Campium bradfordi* Copeland, sp. nov.; type.
41. *Campium molle* Copeland, sp. nov.; type.
42. *Campium subcrenatum* (Hooker and Greville) Presl; *a*, Cochin, *Gamble 14815 cult.*; *b*, southern India, *Gough 61*.
43. *Campium feeianum* Copeland, nom. nov.; Concan, *Law s. n.*
44. *Campium acrostichoides* (Afzelius) Copeland, comb. nov.
45. *Campium humblotii* (Baker) Copeland; Bé Kitus Mountains, northeastern Madagascar, *J. B. Last*, 1900.
46. *Campium salicinum* (Hooker) Copeland, comb. nov.; cotype.
47. *Campium angustifolium* Copeland, sp. nov.; type.
48. *Campium gemmiferum* (Hieronymus) Copeland, comb. nov.; Niger, *I. Barter*.
49. *Campium auriculatum* (Lamarck) Copeland, comb. nov.; Mauritius.
50. *Campium fluviatile* (Hooker) Copeland, comb. nov.; cotype with short-hastate frond, Fernando Po.
51. *Campium gaboonense* (Hooker) Copeland, comb. nov.; *Zenker 3806*.
52. *Quercifilix zeylanica* (Houttuyn) Copeland, comb. nov.; Hong Kong.

PLATE 1. LEPTOCHILUS AXILLARIS (CAVANILLES) KAULFUSS: A, ABNORMAL, PARTLY FERTILE FRONDS; B, BRANCH SHOWING AXILLARY BUDS.

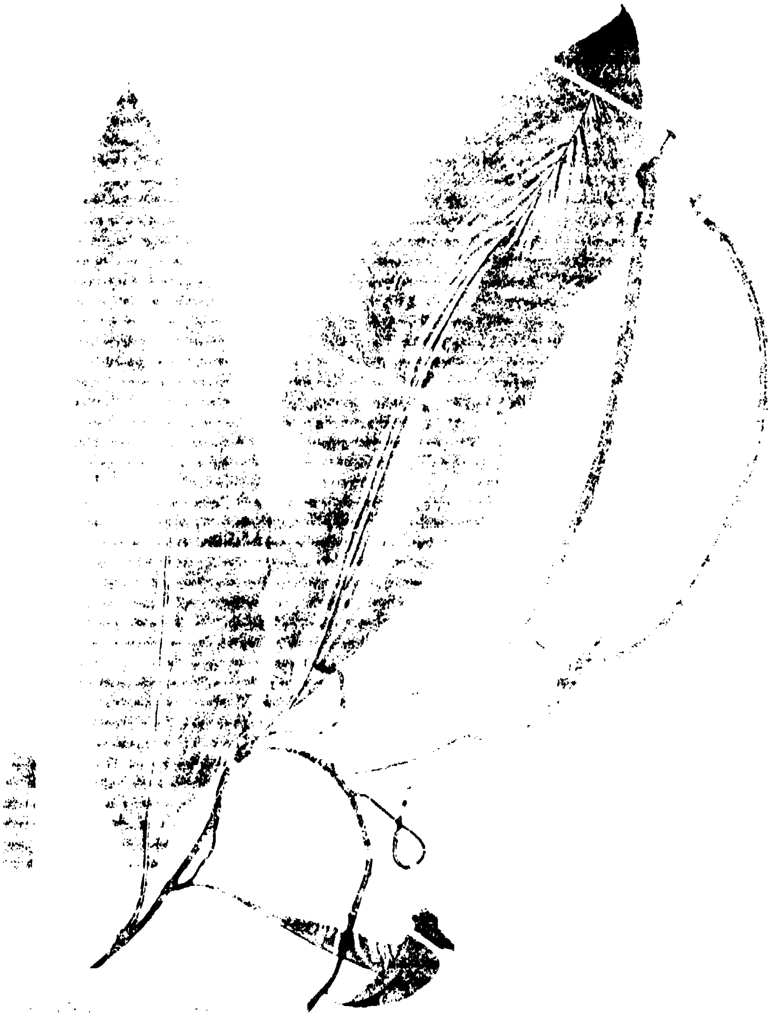
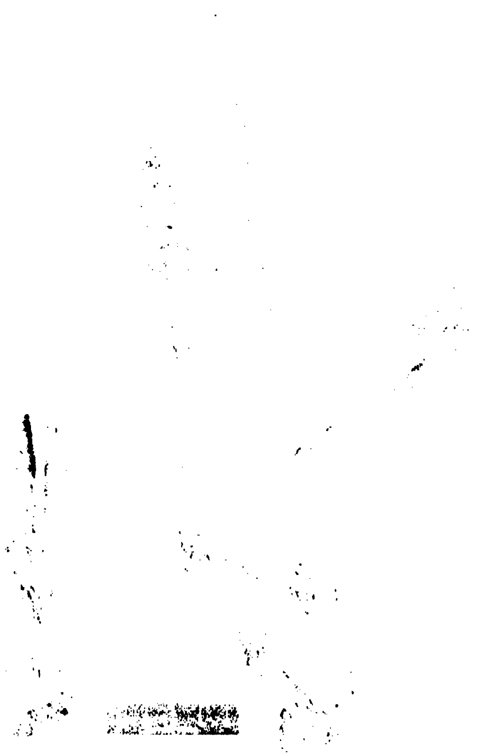


PLATE 2. LEPTOCHILUS PLATYPHYLLUS COPELAND, SP. NOV.; TYPE.



a *b*

PLATE 3. CAMPIUM LINNAEANUM (FÉE) COPELAND, COMB. NOV.: A, ATAVISTIC FORM; B, TYPICAL FORM.

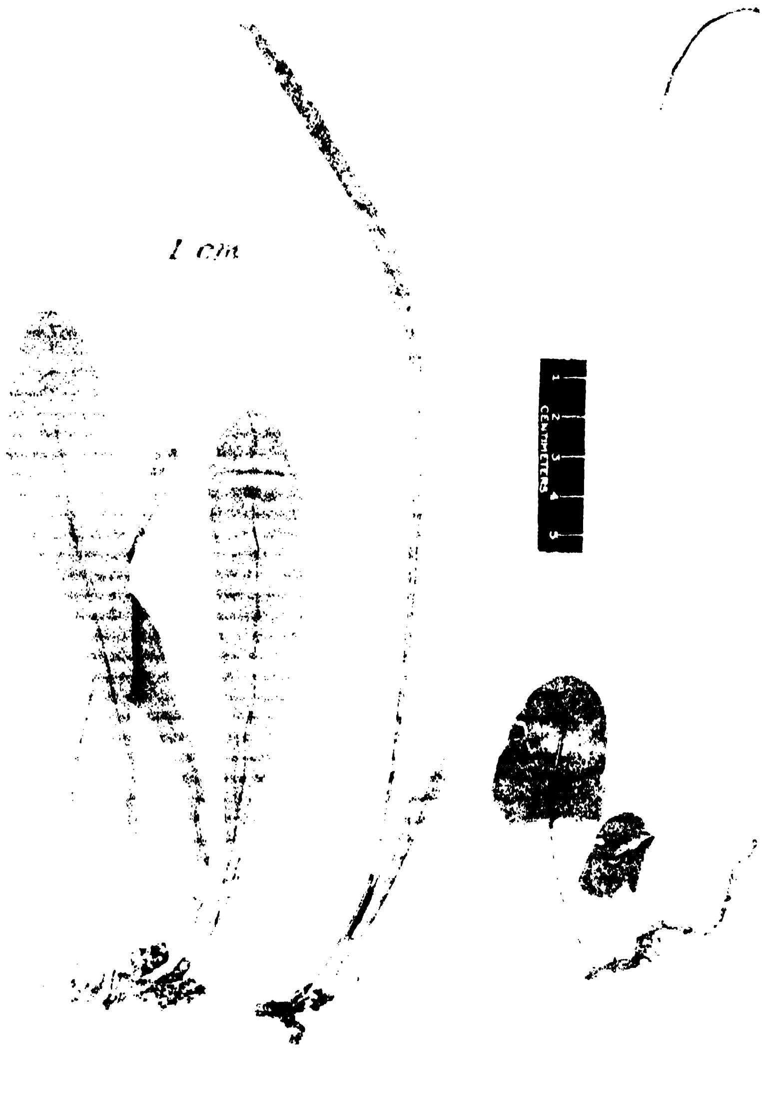


Fig. 1. Campium minus (Fée) Copeland, comb. nov.: Cuming 326, in herbarium Copeland.
2. Campium dilatatum Copeland, sp. nov.: type.

PLATE 4.

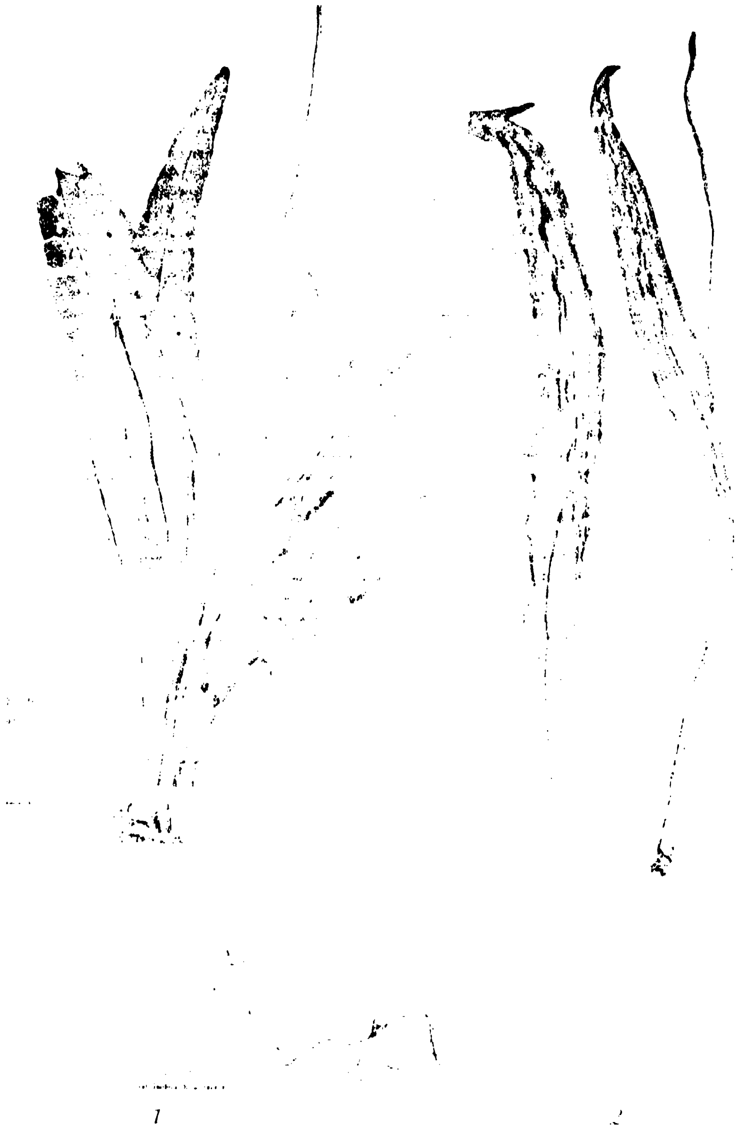


Fig. 1. Campium laciniatum Copeland, sp. nov. (?), simple form. 2. Campium lanceolatum (Fée) Copeland, comb. nov.; small specimen, from Concan.

PLATE 5.

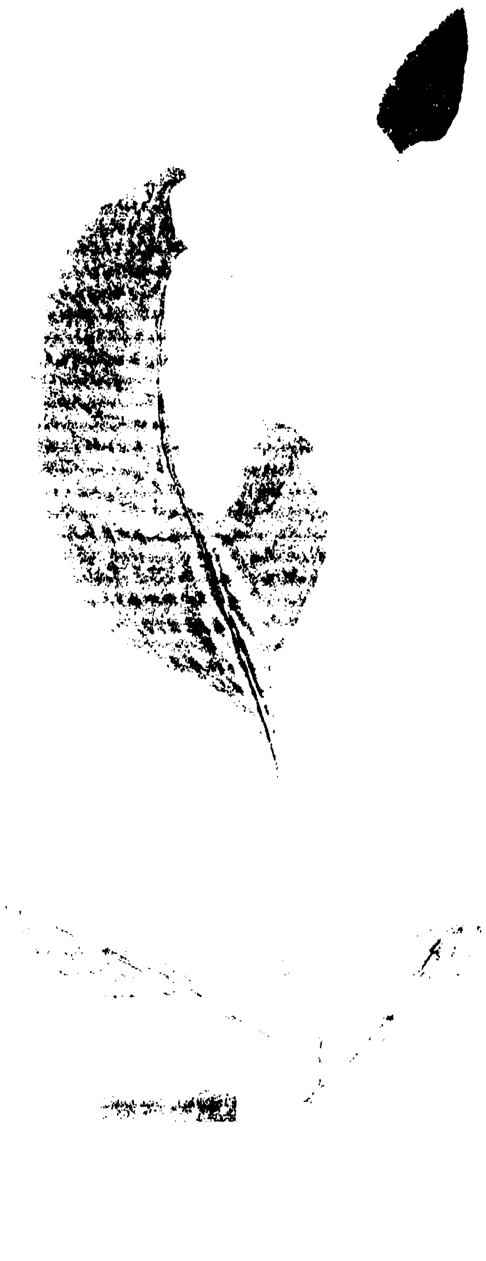


PLATE 6. CAMPIUM OVATUM COPELAND, COMB. NOV.; TYPE.

PLATE 7. CAMPIUM LACINIATUM COPELAND, SP. NOV.; TYPE.

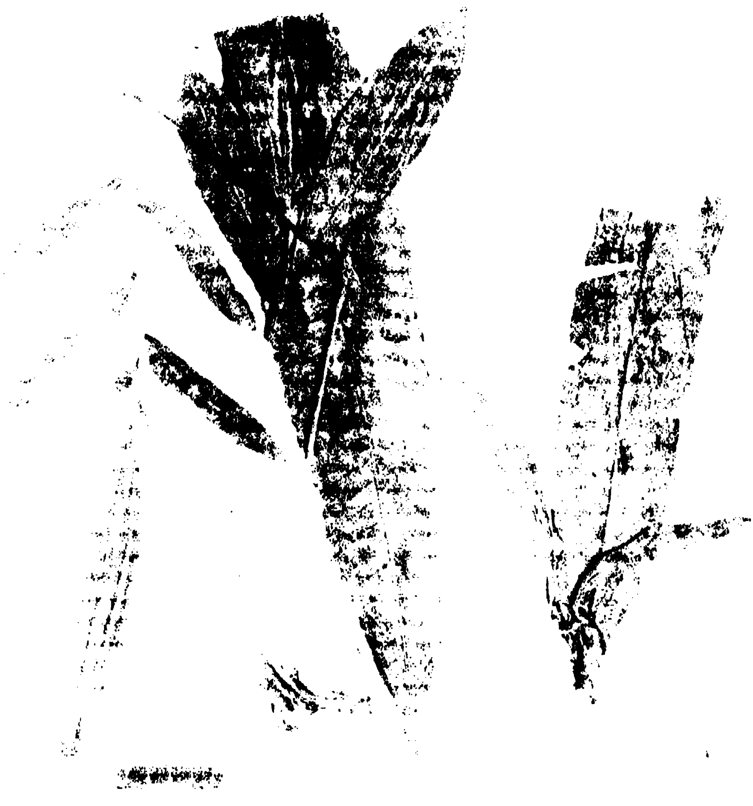


PLATE 8. CAMPIUM SUBSIMPLEX (FÉE) COPELAND, COMB. NOV.: IMPERFECTLY PINNATE FORM.

PLATE 9. CAMPIUM HYDROPHYLLUM COPELAND, COMB. NOV.: TYPE.

PLATE 10. CAMPIUM NIGRUM COPELAND, SP. NOV.; TYPE.

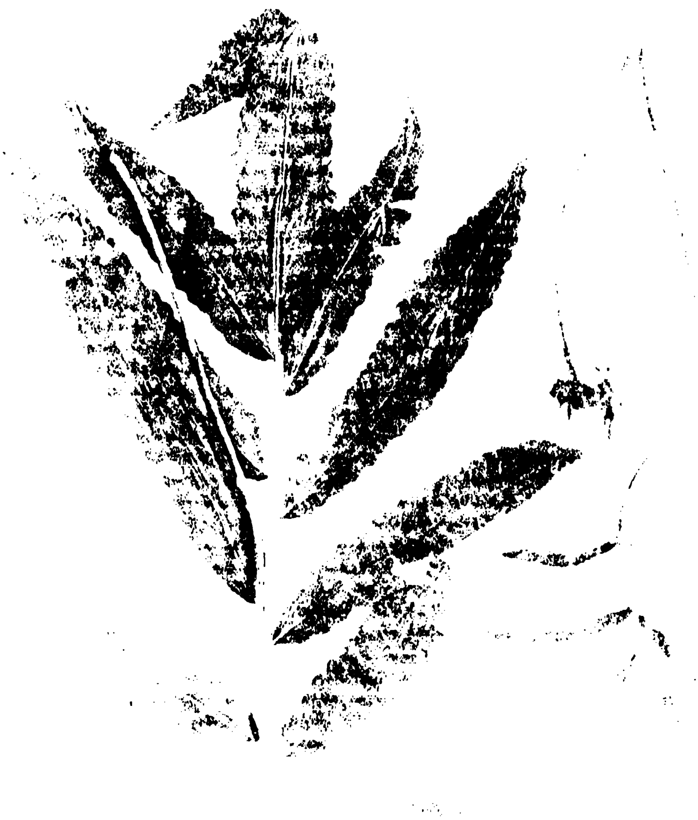


PLATE 11. CAMPIUM PSEUDOSCALPTURATUM COPELAND, SP. NOV.; TYPE.

PLATE 12. CAMPIUM FOXWORTHYI COPELAND, SP. NOV.; TYPE

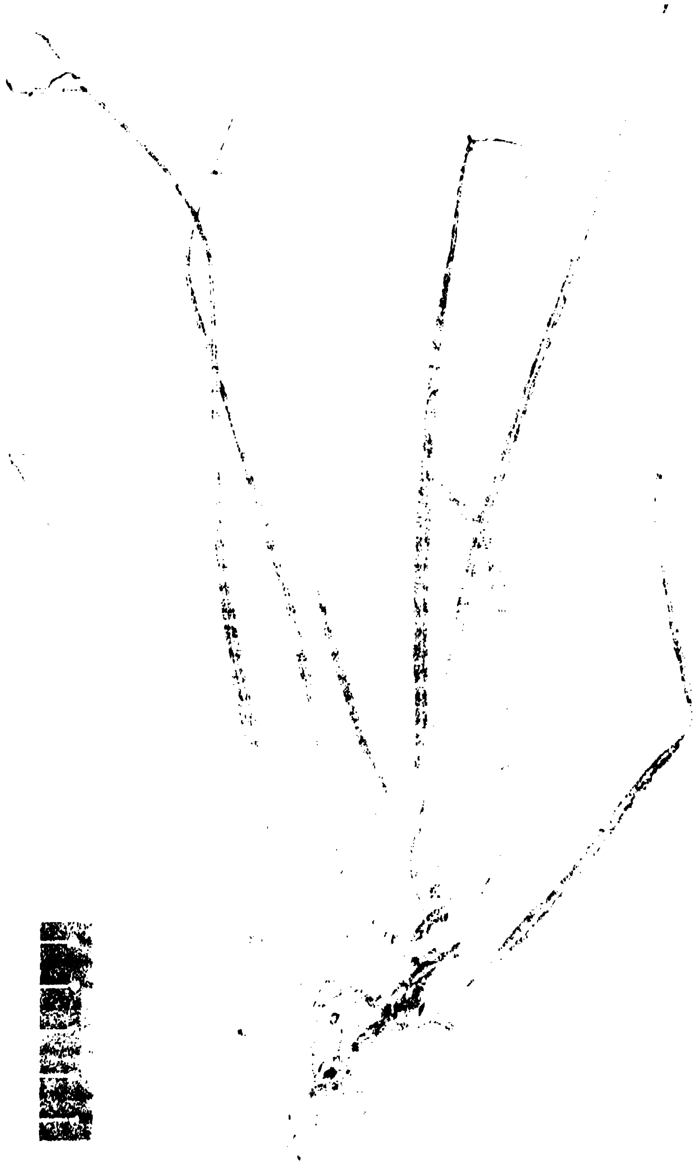


PLATE 13. CAMPIUM TENUISSIMUM COPELAND, SP. NOV.; TYPE.

PLATE 14. CAMPIUM CUSPIDATUM (PRESL) COPELAND, COMB. NOV.; CUMING 161.

PLATE 15. CAMPIUM VALIDUM COPELAND, SP. NOV.: TYPE.

PLATE 16. CAMPIUM SUBCORDATUM COPELAND, SP. NOV.; TYPE.

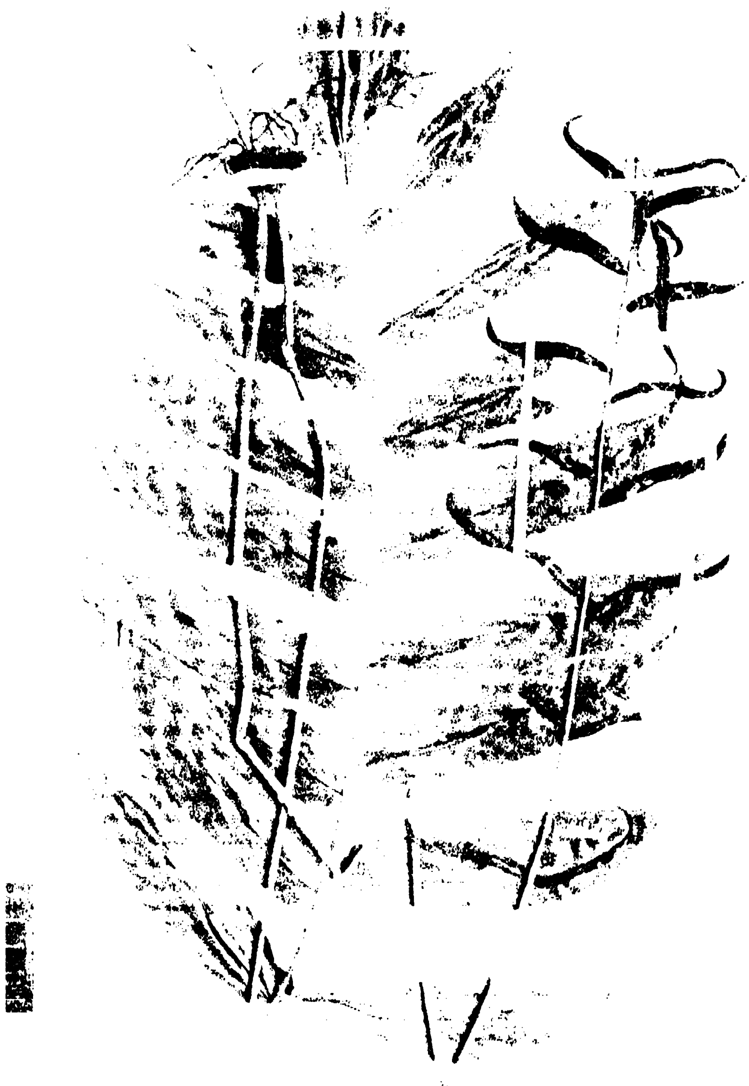


PLATE 17. CAMPIUM INTERLINEATUM COPELAND, SP. NOV.; TYPE.

PLATE 18. CAMPIUM PALUSTRE (BRACKENRIDGE) COPELAND, COMB. NOV.; TYPE.

PLATE 19. CAMPIUM SAMOENSE COPELAND, SP. NOV.; TYPE.

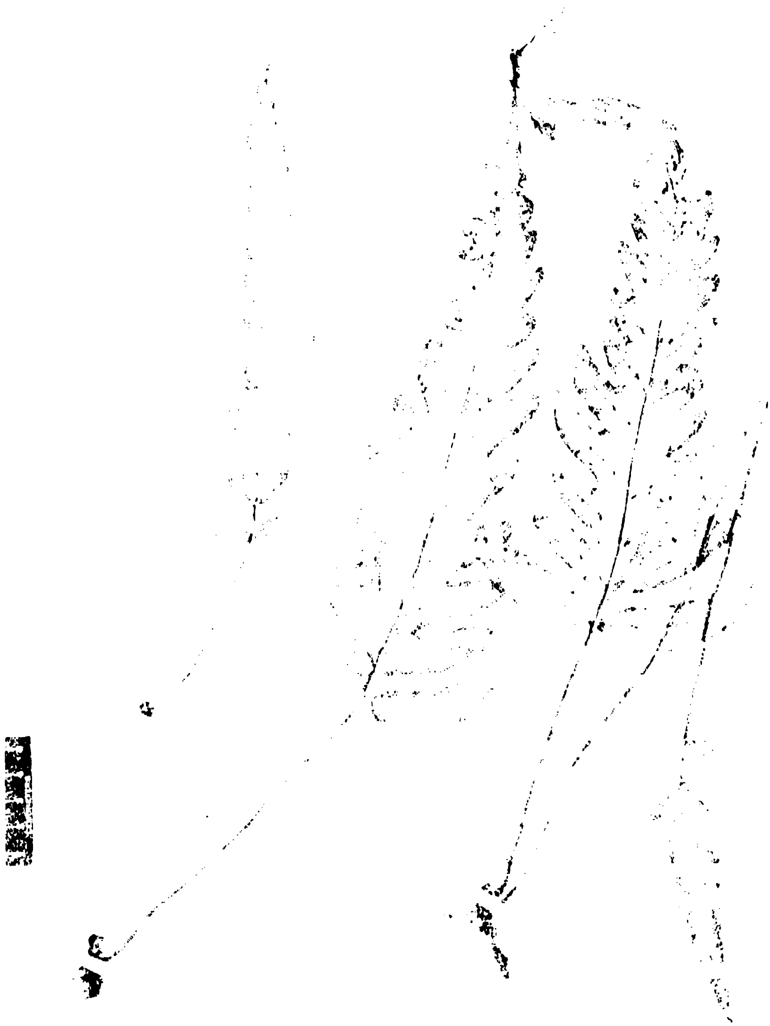


PLATE 20. CAMPIUM RIVULARE (BRACKENRIDGE) COPELAND, COMB. NOV.; TYPE.

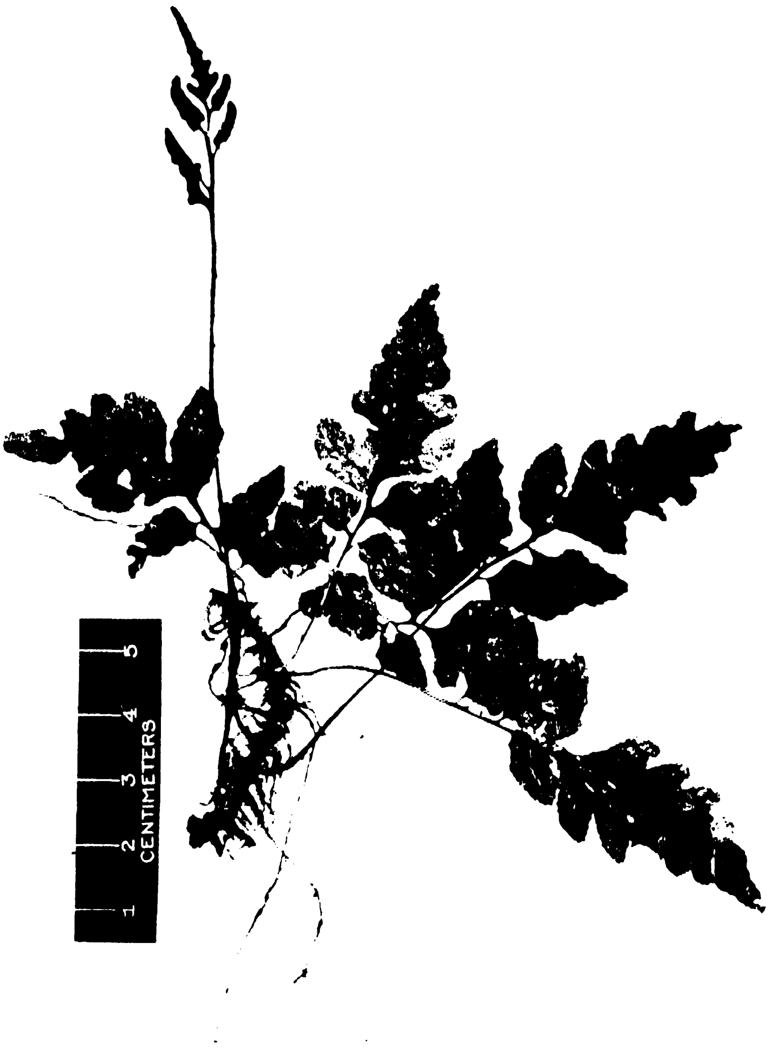


PLATE 21. CAMPIUM PARVUM COPELAND, SP. NOV.: TYPE.

PLATE 22. CAMPIUM ARGUTUM (FEE) COPELAND, COMB. NOV.; LARGE FORM, McLEAN ET AL., S. N.

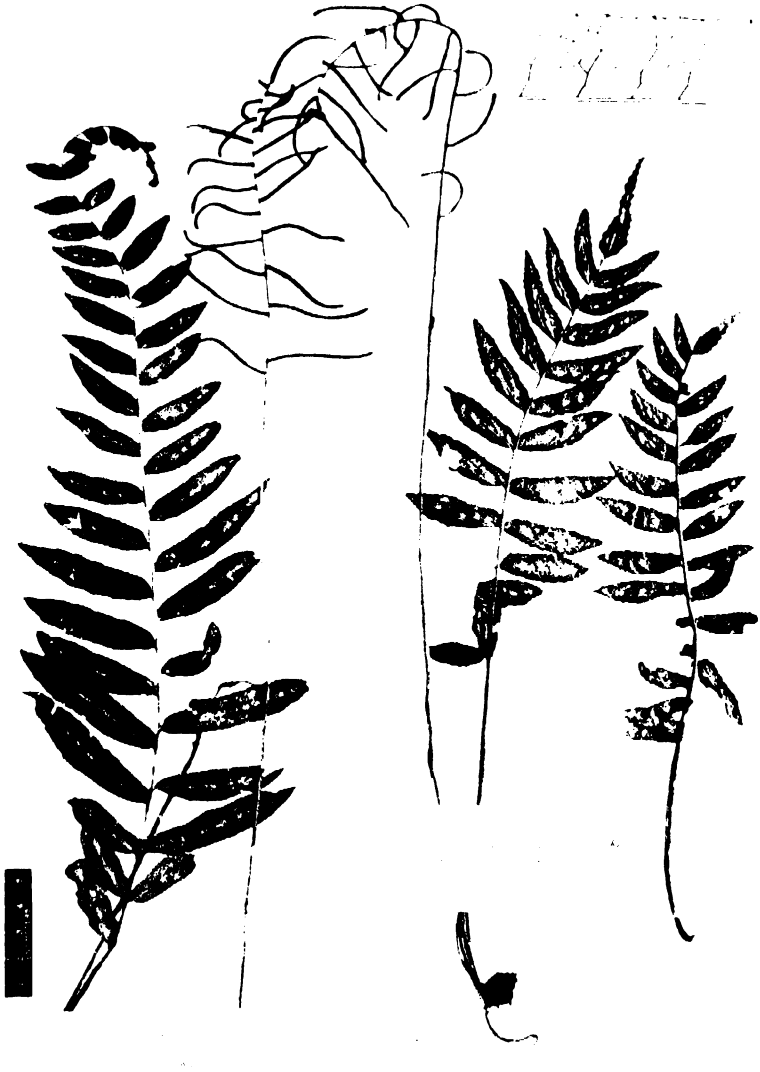


PLATE 23. CAMPIUM SEMICORDATUM (BAKER) COPELAND, COMB. NOV.; COTYPE ON THE RIGHT.

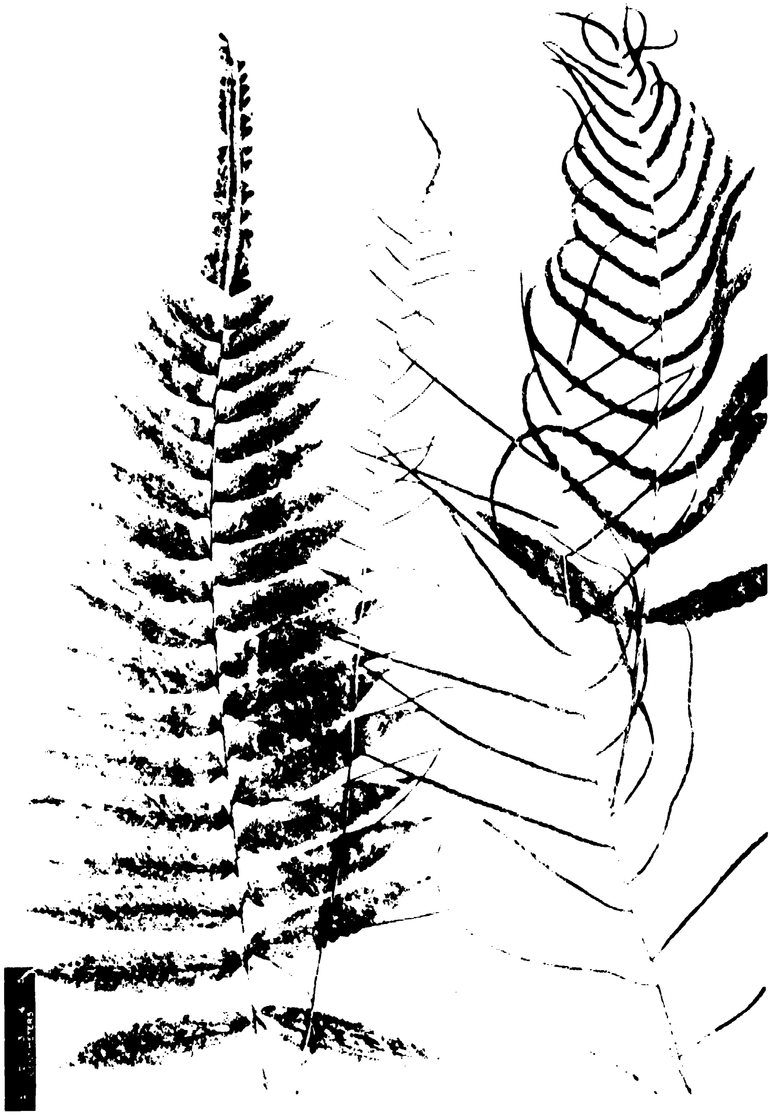


PLATE 24. CAMPIUM SEMICORDATUM (BAKER) COPELAND, COMB. NOV.; COLLECTED BY BEDDOME.

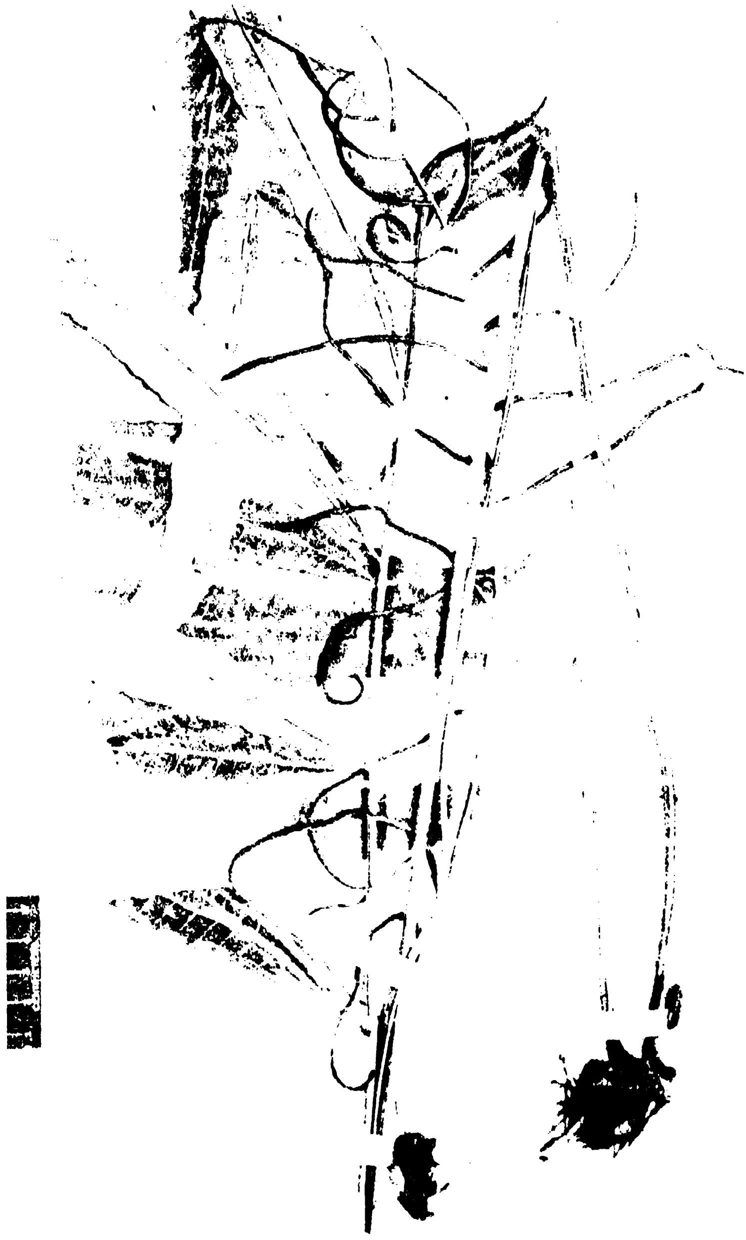


PLATE 25. CAMPIUM LANCEUM COPELAND, SP. NOV.; TYPE.

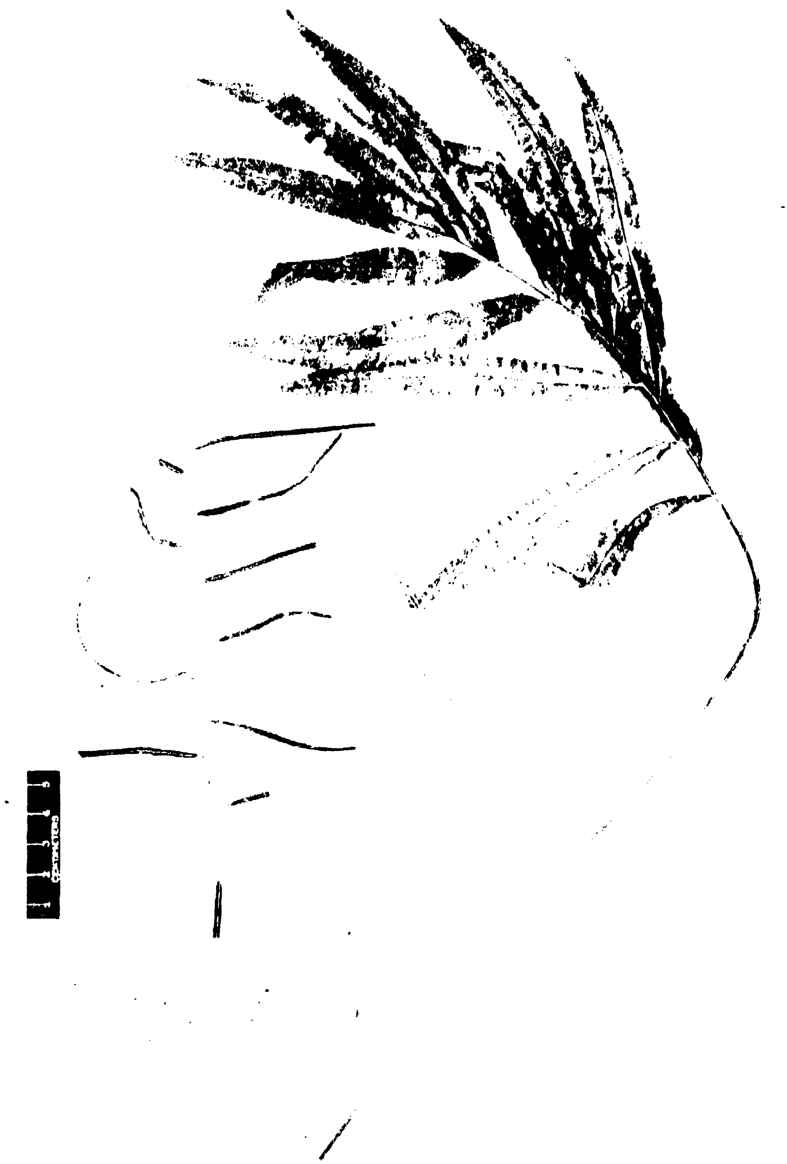


PLATE 26. CAMPIUM CRISPATULUM (WALLICH) PRESL; WALLICH SPECIMEN IN KEW HERBARIUM.

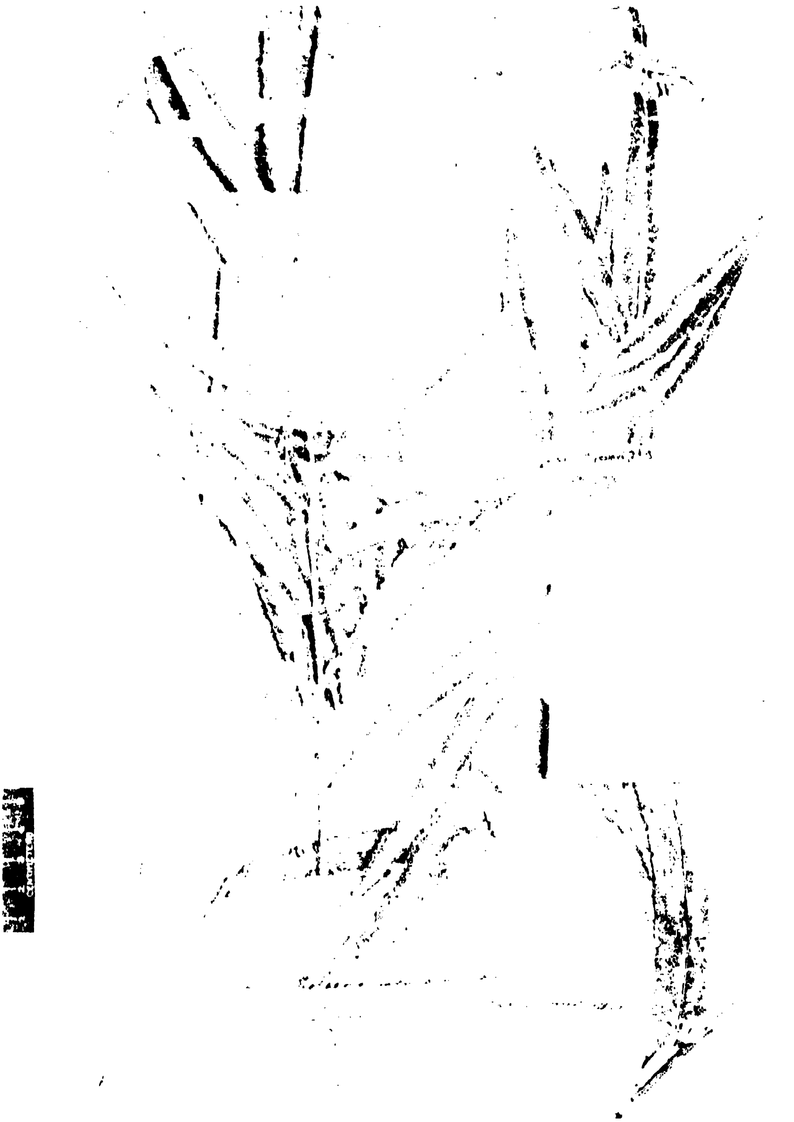


PLATE 27. CAMPIUM UNDULATUM (WALLICH; HOOKER) PRESL; TYPE.

PLATE 28. CAMPIUM BRADFORDI COPELAND, SP. NOV.; TYPE.

PLATE 29. CAMPIUM MOLLE COPELAND, SP. NOV.; TYPE.

PLATE 30. CAMPIUM ACROSTICHOIDES (AFZELIUS) COPELAND, COMB. NOV.; SIERRA LEON, SCOTT ELLIOTT 4048.

PLATE 32. CAMPIUM FLUVIATILE (HOOKER) COPELAND, COMB. NOV.: COTYPE.

A CYTOLOGICAL STUDY OF COCOS NUCIFERA LINNÆUS

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SEVEN PLATES

For many years the reduction divisions in the mother cells have been studied and described in various forms with the object of determining the time, the nature, and the extent of the sequence of events during the process. The structure, the behavior, and the differentiation among chromosomes and the part they play in heredity have been also carefully considered. That the number of chromosomes is reduced to one-half previous to the union of the gametes became universally accepted, but the method by which reduction divisions or meiotic divisions are accomplished is still not so clear, because of the numerous diversified accounts and confusing views regarding the details of meiotic divisions, which need not be reviewed here. The diversity of opinion is partly due first, to the complexity of the process, coupled with certain unavoidable flaws in the technic essential to the study of the process; second, to the difficulty of interpreting the details of the series of stages under the condition in which the delicate material is studied; and, third, to the specific differences exhibited by the various organisms during the meiotic divisions. Any additional cytological study, therefore, is of considerable interest. Since the anthers of *Cocos nucifera* Linnæus are rather favorable material for such an investigation, this piece of work was undertaken with the hope of throwing more light upon the phenomenon of synezesis, or synapsis, and its relation to reduction division.

MATERIAL AND METHODS

The material used in this study was collected from two places in Luzon, Philippine Islands, where the tree is extensively cultivated. One portion of it was collected on April 7, 1926, from Mauban, Tayabas Province, while the other and the greater portion was collected on May 13, 1926, from San Pablo, Laguna Province. The two sets of material were fixed in the field from

the inflorescences just beginning to emerge from the axils of the leaves. The samples were taken from the different parts of the inflorescence and fixed separately. Thus, those taken from the tips of the spikes were fixed separately from those taken from the middle part and separately from those collected from the base.

The fixing fluids used were 1 per cent chrom-acetic acid with ten to fifteen drops of 1 per cent osmic acid to 50 cubic centimeters of the solution, and Flehmming's strong chrom-osmic acetic acid solution. The young anthers were mostly cut into two parts and some were trimmed at both ends of the anther before they were placed in the fixing fluids. Both fixatives gave fairly satisfactory results.

The material was embedded in 50° to 52° C. paraffin, and cut from 5 to 10 μ thick with some 10 to 15 μ thick and stained with Haidenhain's iron-alum hæmatoxylin.

RESTING STAGE TO SYNEZESIS

The pollen mother cells following the last mitosis in the archesporium are more or less polygonal in outline and fit tightly together with no spaces between them. There is as yet no rounding of the cell wall. The cytoplasm is exceedingly dense and granular with a very few small vacuoles. The nucleus is comparatively large, somewhat spherical, and possesses a well-defined nuclear membrane. It is usually found lying very close to one side of the cell, especially during prophase and synezesic stages; but soon after the spireme begins to emerge and spread throughout the nuclear cavity, the nucleus seems to move toward the central part of the cell. There were comparatively few cases in which the nucleus was found close to one side of the cell during the open spireme stage. Even in such cases, the position of the nucleus compared with that in the earlier stages is farther from the wall.

The scarcity of the resting stage of the nucleus, during the early stage of the anthers of *Cocos nucifera*, seems to indicate that it lasts only for a short time, for it soon goes into prophase. Plate 1, fig. 1, represents a definite resting stage. It is characterized by the somewhat uniformly distributed chromatin reticulum throughout its cavity. At the intersections between the chromatin threads and the delicate fibers connecting them there are very minute nodelike structures or granules of different sizes. During this stage the chromosomes were completely resolved into a network of threads and their indivi-

duality is completely lost. There is no trace whatever of parallelism of the threads.

Heterotypic prophase.—The early prophase of the first meiotic division is differentiated from the resting stage by the gradual and progressive increase in size of the chromatin granules or nodelike structures in the reticulum, the thickening and contraction of the threads, and the decided enlargement of the nucleus. As the nuclear changes advance, the granules come closer together and take a deeper stain, while the chromatin threads contract and become thicker and shorter. The reticulum as a whole loses the even and uniform characteristic, as represented on Plate 1, fig. 2. The meshes become larger and different in size. Some of the threads which have been lying far apart are apparently brought near together by their gradual contraction. Plate 1, fig. 3, shows the condition of the reticulum before synezesis. The chromatin threads are irregularly thickened, the nodal structures are more prominent, and the meshes become smaller.

Synezesis.—The gradual withdrawal of the chromatin threads, or network, from the nuclear membrane marks the beginning of synezesis or synapsis as represented on Plate 1, fig. 4. During the progress of events leading to this stage there is a notable and irregular progressive increase in diameter of the threads, which seems to be brought about not only by contraction but also by fusion of material from the chromatin threads that happen to run parallel to one another. Furthermore, there is an indication of a flow of material from one thread to another, or from one part of a thread to another part, similar to what Cleland(5) observed in *Oenothera franciscana*. A greatly enlarged portion of the thread is represented on Plate 1, fig. 5. The contraction continues steadily until almost all the threads and meshes in the reticulum are drawn into a more or less compact mass that lies usually near the side of the large nucleolus and at one side of the nuclear cavity. At this stage the chromatin material appears as a lumpy mass with some globular projections, and a few small loops may be found on one or two sides of the synezesic knot. The pollen mother-cell nucleus remains in this condition for a long period, for the majority of the nuclei of the pollen mother cells of the younger anthers are usually observed in synezesis. A series of stages leading to synezesic contraction are represented on Plate 1, figs. 6 and 8, and on Plate 2, figs. 9 and 10. Very frequently fine strands extend across the nuclear cavity. Plate 1, fig. 7, shows a portion of

a greatly magnified spireme taken from the nucleus represented in fig. 6. Figure 10 represents a definite stage of synezesis after a maximum contraction is attained. The nature of the spireme at this stage is very difficult to determine with accuracy. A careful examination of some thin tangential sections, however, seems to reveal that the chromatin nodes, or granules, were brought very close together by contraction. These granules are found arranged in most cases in single rows and in a very few instances in two rows running side by side. Since these few cases of the parallel arrangement of the granules are so rare in the material examined it is quite obvious that the spireme is univalent in nature. From this fact the condition observed in *Cocos nucifera* can by no means be compared either with Digby's(9) findings in *Osmunda* or with the writer's(20, 21) in *Elodea*, in which the parallel arrangement of the granules or the double nature of spireme is very evident. All the indications tend to agree with the observations of Cleland(5) on *Oenothera*, in which the scattered chromatin granules from a thin-thread reticulum are brought together into a thick spireme by a process that consists largely of the contraction of certain threads and the absorption of their contents into the body of other threads, a process which he believes involves occasional parallelism. Plate 2, fig. 11, represents a very small portion of the spireme in the same stage as fig. 10.

That the synezesis is brought about by the contraction of the chromatin reticulum and by the decided enlargement of the nucleus, as has been definitely observed in *Lactuca* by Gates and Rees(13) and in *Elodea* by the writer(20, 21), is also very evident in *Cocos nucifera*. When the size of the contracted reticulum is compared with that of the resting condition and the cavity of this nucleus with that of the synezesic stage a relatively great difference is noted. The synezesic knot is distinctly smaller than the original reticulum, while the cavity of the resting stage is comparatively smaller than that of the synezesic stage. This is essentially contrary to Lawsons's view point.

The nucleolus may, or may not, be entirely inclosed by the chromatin knot. Generally, however, it is found at one side of the synezesic knot, and sometimes is partly covered by a few projecting loops of the spireme. There is no material change observed in the nucleolus up to this stage except that it has increased in size, almost twice as much as during the resting stage.

Open spireme.—After the period of the greatest contraction, the chromatin mass begins to loosen and it becomes a continuous univalent short and thickened thread, known as the spireme, which extend slowly throughout the nuclear cavity. Free ends are rarely observed. During this gradual distribution of the spireme, beautiful loops corresponding to the gametic number of the chromosomes are formed. At this stage the spireme appears more uniform in diameter, although in some places it may have an irregular thickening. Plate 2, figs. 12, 13, and 15, illustrates this gradual unfolding of the spireme from the synezesic knot. Judging from the frequency of this stage in the several sections examined, it appears to be of long duration. There is no sign of splitting observable, and the spireme, unlike that of *Elodea*,(20, 21) does not show the double nature. The spireme is distinctly single and more or less smooth and uniform. Plate 2, fig. 14, is a detailed drawing of a greatly magnified portion of the spireme taken from a superficial section.

While the spreading of the spireme is taking place the nucleolus begins to separate from the spireme and its size is gradually reduced. This reduction of the size of the nucleolus is significant. It seems that the nucleolar content contributes in someway to the formation of the thick spireme. Cleland(5) shows a figure that indicates a clear connection between the nucleolus and one end of the spireme. It is also quite evident that the nucleolus at this stage takes the stain very lightly, and a few clear rounded spaces are developed.

Second contraction.—Shortly after the spireme is uniformly spread into wide loops radiating throughout the nuclear cavity (Plate 3, fig. 16), the nucleous passes into another interesting phase of meiosis known as second contraction. Early stages leading to this phase are represented on Plate 3, figs. 17, 18, and 19. The first indication noticed is the gradual shortening and approximation of the sides of each loop and the progressive thickening and condensation of the chromatin thread. Up to this stage the chromatin thread remains distinctly single and there is no sign at all of fission.

As the process of shortening and condensation proceeds, the loops become shorter and thicker and their two sides approach each other closer and closer, while the spireme as a whole undergoes a slow process of transverse segmentation. The segmentation becomes evident from the time the loops begin to rearrange themselves in the nuclear cavity, and it is apparently

completed during the later stage of the second contraction. It is indicated by the formation of a constriction usually at the distal end of the loop (Plate 3, figs. 17 and 18). The loops are gradually detached while the massing of the filaments is going on. In a critical study of the chromatin filaments at this stage, particularly on the two sides of the loops, the writer failed to find any sign of longitudinal splitting or fission. This shows that each side of the loop represents a univalent chromosome, contrary to the interpretation of Gregoire(14, 15, 16) and his followers.

While the nucleus advances into second contraction, the greater part of the spireme filaments become gradually collected and entangled at the side of the nucleolus. During this period the visible identity of the individual parts of the spireme is somewhat lost, although in some cases isolated portions may remain independent and free. Plate 3, figs. 20 and 21, shows the character of the late stages of the second contraction in *Cocos nucifera.*

It is interesting to notice that during the later period of the second contraction there is a reduction in size of the nucleus. The pollen mother cells, which during the resting stage up to the later stage of synezesis were packed tightly together, are beginning to round off and separate from one another and large spaces among them are developed.

Diakinesis.—The massing of the chromatin material during the second contraction is of short duration only, for it soon loosens and proceeds into diakinesis. This is perhaps the reason why this stage was overlooked by some of the previous investigators. As the nucleus advances into this stage, the bivalent segments are gradually thrown toward the periphery of the nuclear cavity and they begin to show a somewhat clear outline. On Plate 3, fig. 21, the bivalent chromosomes in varying stages of evolution can be seen emerging from the knot of the second contraction. On one side of the nuclear cavity are three distinct loops coming out from the knot and moving toward the periphery, while on the other side one or two loops are in the process of organization. Some of the chromosomes are irregularly thickened and more or less spirally twisted along their entire lengths, others show distinctly a double character, still others are slender and have a somewhat uniform diameter. In the last the chromosomes are univalent but joined end to end. During this period of nuclear activity the chromosomes usually tend to assume a position close to the nuclear mem-

brane. This peripheral arrangement is especially conspicuous after considerable thickening and condensation of the chromosomes have occurred. The chromosomes represented on Plate 4, fig. 22, show a definite stage after the second contraction. On the same plate fig. 23 illustrates a more-advanced stage in which most of the young heterotypic chromosomes are lying close to the peripheral part of the nucleus.

While the paired chromosomes grow thicker and shorter the daughter chromosomes, or the members of the pairs, begin to separate or untwist. This process may be followed in a series of stages represented on Plate 4, figs. 23, 24, 25, 26*a*, and 26*b*, and Plate 5, fig. 27. The usual result of this separation, or untwisting, is the evolution of the configuration of the chromosomes into various shapes. In some cases they become more or less like J's, O's, X's, and Y's, but in very many cases they are found having the characteristic shapes of U's and V's. A few fine and delicate strands are observed connecting separate chromosomes, and some run from the chromosomes to either the nuclear membrane or nucleolus. These strands are obscurely granular, and they may appear straight, curved, or crooked. Sometimes they connect each other and form a sort of net (Plate 4, fig. 26*b*). The chromosomes now appear more homogeneous in structure, and they take more uniformly a deeper stain. Their outline is somewhat undulated, there is no splitting, and a great diversity is shown in their length. Plate 5, fig. 28, represents three greatly magnified bivalent chromosomes with Y, U, and X shapes and in the same stage as Plate 4, fig. 26.

Plate 5, fig. 29, represents an interesting stage after the greater contraction and thickening have occurred. The chromosomes present a ragged appearance. They are mostly V-shaped, although some possess either U or ring forms. There is no material increase in the number of strands connecting one chromosome to another or the chromosomes to the nuclear membrane. Still later stages of diakinesis are shown in figs. 30 and 31. The paired chromosomes appear definitely individualized with a more-distinct outline. Some of them simulate dumb-bell-shaped bodies, and others, straight and bent rods. As in the earlier stages, they are of different lengths and each chromosome is composed of two short structures, so closely appressed to one another that its double nature is often difficult to detect.

The number of bivalent chromosomes at this stage of the nuclear development was carefully considered. Several counts

from different sections and from different preparations were made. In general the bivalent number observed was sixteen, and in a very few instances fifteen. These few exceptional cases, however, can be accounted for as due to the frequent overlapping of the chromosomes.

During the late diakinesis stage and previous to the dissolution of the nuclear membrane, there is a notable decrease in size of the nucleolus and also of the nuclear cavity. The shape of the nucleolus, as well as of the nuclear cavity, is apparently modified from spherical to elongated or ovoid. The nucleolus, which stands out prominently during the earlier stages of the pollen mother cell because of its great affinity for stain, begins to show a marked decreasing affinity for the stain. Its nucleolar content is greatly reduced as shown by the fact that two or more clear round spaces or intra-nucleolar vacuoles are developed.

The nuclear membrane becomes more or less granular and irregular or wavy in outline. Its definite and smooth appearance is gradually lost, while the cytoplasm around it becomes denser and denser. That the nuclear membrane and the nucleolus disappear simultaneously at the time the fibers with granular appearance emerge from at least the three sides of nucleus is quite evident, as has been observed in *Elodea*.(20, 21) Plate 5, figs. 32 and 33, represents two characteristic stages, one closely following the other, of the late diakinesis. The multipolar spindle fibers are granular in structure and quite distinctly attached to the definite parts of the chromosomes. As the formation of the spindle fibers progresses, the nuclear cavity becomes smaller until it is completely filled by the fibers and by the dense cytoplasmic material. The chromosomes aggregate into a somewhat close irregular mass at the center of the pollen mother cell.

HETEROTYPIC MITOSIS

As the multipolar spindle fibers grow in number they are gradually rearranged into bipolars as indicated on Plate 5, fig. 34. The spindle fibers are seen stretching and have lost their granular character, while the chromosomes, which by this time have undergone a complete process of condensation, are moving toward the equatorial plane and they appear as bent rods, pestlelike, or somewhat globular. The chromosomes seem not to reach the equatorial region at the same time, but as soon as they reach this region, they become arranged more or less evenly in one plane and in a very symmetrical manner.

A polar view of the heterotypic chromosomes is shown in fig. 35. The sixteen bivalent chromosomes are very evident, and they display the same variation in shape. One of the sixteen heterotypic chromosomes is strikingly larger than the others, and the longitudinal fission between the two daughter chromosomes is very distinct, while three other chromosomes are smaller in size. They appear somewhat pestlelike and do not show longitudinal fission. This is one of the most favorable stages for counting the chromosomes for they are not crowded and seldom overlap each other. The several counts made at this stage revealed the same prevailing number, sixteen, that was obtained previously from the younger stages.

At the equatorial plate the heterotypic chromosomes may be arranged radially or obliquely. Each chromosome has a small bundle of spindle fibers attached to the inner end of each daughter segment, and the outer end extends perpendicularly from the spindle to the cytoplasm. In some cases, however, the chromosomes lying near the periphery or near the central part may be found arranged tangentially to the spindle. In this case the point of attachment of the spindle fibers to the daughter chromosomes may be at either end or at, or near, the middle region.

A typical side view of the metaphase stage of the heterotypic mitosis is represented on Plate 6, fig. 36. The general appearance is as if the contraction of the spindle fibers gradually pulled the two longitudinal halves apart. At the middle part, between the two separating daughter segments of each bivalent chromosome, there is a thickening which consists of the two ends that have not yet separated. Apparently, judging from this figure, all the chromosomes divide at the same time.

Soon after the daughter chromosomes have separated they immediately diverge at their equatorial ends, and take on the V-shaped or, sometimes, the J-shaped forms, with apex toward the pole. As they move toward the poles, they pass through a slight process of condensation and differentiation until they reach the poles. In some cases a sign of splitting preparatory for the homœotypic mitosis is observed. Plate 6, fig. 37, represents an anaphase stage. The V- and J-shaped chromosomes are midway to the poles. A late anaphase is indicated in fig. 38. It illustrates the stage just after the daughter chromosomes have reached the poles. At this stage the chromosomes still retain their V- or J-shapes, although in some cases, their two ends are somewhat separated and appear as bent rods. Figure

39 shows a polar view of the sixteen univalent chromosomes at about the same stage as that of fig. 38. The fission of the chromosomes in preparation for the succeeding homœotypic mitosis becomes evident as they are congregated at the poles of the spindles. As the daughter chromosomes gather and mass together at the poles, they become surrounded by dense cytoplasm. Then a clear space, or vacuolelike region, developes between the chromosomes, the boundary of which becomes the membrane of the daughter nucleus. This stage is represented on Plate 6, fig. 40, a telophase stage of the heterotypic mitosis. While this clear space and the nuclear membrane are in the process of organization the chromosomes expand and become longer and thinner. They radiate outward across the flattened region of the reconstructing daughter nucleus. Their free ends begin to curve, and because of this curving the end of one arm of a chromosome is brought into contact with an arm of another chromosome and those ends apparently fuse together. This fussion of the end of one chromosome to another seems to form a spireme of short duration only, for it is soon transversally segmented. This is shown by the fact that in the succeeding stages, although the shape and the position of the chromosome are apparently retained, the writer failed to find a distinct continuous spireme among the sections examined. Plate 6, fig. 41, represents a stage closely following the one shown in fig. 40. The nuclear membrane is definitely formed and the daughter J- or V-shaped chromosomes are seen connected with one another by delicate strands. Still more advanced stages of the reconstructing daughter nuclei are indicated on Plate 7, figs. 42 and 43. The daughter chromosomes with somewhat ragged appearance and partially condensed are more or less evenly distributed in the nuclear cavity. The nucleus continues to grow in size and becomes rounded. The nucleolus is relatively small and frequently is hidden between the chromosomes and does not appear clearly in the daughter nucleus.

HOMŒOTYPIC MITOSIS

The succession of events during the division of the daughter nuclei is extremely rapid. The period covered from the time the nuclear membrane is formed in the late telophase, up to the reorganization of the daughter chromosomes preparatory for the second division is of short duration. The daughter nuclei appear not to pass into anything resembling a typical resting condition.

Shortly after the nucleus has sufficiently increased in size and assumed the spherical form and the chromosomes have attained a more distinct outline, the nuclear membrane breaks down and the multipolar spindle fibers appear at different sides of the nuclear cavity. The cytoplasmic materials diffuse into the nuclear cavity, while the chromosomes collect closely together, as in the previous division. The spindle fibers radiate into this mass, and each chromosome is attached at, or close to, its end by a small bundle of fibers. As in the heterotypic division, the multipolar spindle fibers become bipolars while the chromosomes become arranged in the equatorial plate. Plate 7, fig. 44, shows a polar view of the two sets of chromosomes more or less evenly distributed. There are sixteen monovalent chromosomes in each set. Like the heterotypic chromosomes they display various shapes; some of them are somewhat globular while others resemble short bent rods, but most of them are pestlelike or dumb-bell-shaped.

The two spindles may lie parallel or at right angles to each other, or in some cases in a V-shaped position. Plate 7, fig. 45, represents a side view of two spindles at the metaphase stage lying almost parallel to each other. Figure 46, on the same plate, is about the same stage as fig. 45 and shows a side view of one spindle and more or less of an oblique polar view of the other spindle. This indicates that the two spindles lie somewhat at right angles to one another. The majority of the chromosomes seem to be attached at the end or very close to it. They exhibit the same variations in shape as did the daughter chromosomes, which were observed in the equatorial plate, appearing during their separation in the heterotypic mitosis. As the granddaughter chromosomes move away from one another and proceed toward the spindle poles they become V-shaped as in the previous division, but as they approach the poles they become considerably straightened out. During this stage no fission was observed. At the poles the chromosomes draw together in a mass and become surrounded by a denser cytoplasm, which is followed by a gradual expansion and the appearance of a clear space between them. Ultimately, the nuclear-limiting membrane makes its appearance, while the chromosomes advance into a process of alveolization. Plate 7, fig. 47, represents a typical telophase stage just before the formation of the nuclear membrane and nucleolus, while fig. 48 shows one of the granddaughter nuclei after the nuclear membrane and the nucleolus made their appearance.

DISCUSSION

The series of changes preceding the development of the heterotypic spireme up to the formation of the bivalent chromosomes have been the important subject for research and debates for the last twenty-five years. Much work has been done and published on the cytology of animals and plants. Various accounts and interpretations of reduction division were offered and as a result two important theories were advanced; namely, parasynapsis and telosynapsis. Both of these theories are very conspicuous in recent literature. The parasynapsis interpretation may be said to have been initiated by the excellent work of Hans Von Winiwarter(25) and strongly supported by Gregoire,(14, 15, 16) A. and K. E. Schreiner,(23, 24) Allen,(1) Berghs,(2, 3) and others. According to this scheme the spireme consists of a double-thread system which arises by the union of homologous parental elements during the heterotypic prophase. Thus, the resulting spireme is bivalent in nature, and each of its segments is composed of two somatic chromosomes arranged side by side. The telosynaptic interpretation was advanced by Farmer and Moore,(10) and supported by Fraser,(11) Mottier,(19) Digby,(9) and others. The double-thread system in the heterotypic prophase, according to this scheme, arises by the pairing of the threads derived from the halves of the somatic chromosomes which have split by process of alveolization. Therefore, the resulting spireme from this pairing is univalent in nature, and any segment of it consists of a single somatic chromosome and the union of the paternal and maternal chromosomes takes place at the second contraction. A slight variation of this scheme, however, has been observed in *Oenothera*, by Gates,(12) Davis,(6, 7, 8) and Cleland;(5) in *Fucus* and *Cutleria*, by Yamanouchi;(26, 27) and in *Lactuca*, by Gates and Rees.(13) The spireme in the heterotypic prophase is observed as a single unsplit filament, which arises by an irregular process of condensation, and the split preparatory for the second contraction is first observed only in the heterotypic anaphase.

The foregoing description of the reduction division of *Cocos nucifera* presents strong evidence for the telosynaptic interpretation. During the early heterotypic prophase the chromatin threads are arranged in a very irregular manner and they are mostly found unpaired. Although in some cases it is possible to find threads that run closely parallel to one another for some distance, the degree of parallelism is too insignificant to amount to anything in support of the parasynaptic interpretation. This

occasional parallelism of the threads may be considered as mere chance, occurring in certain conditions as presented by *Cocos nucifera*. All my observations seem to corroborate the accounts of Gates,(12) Davis,(6, 7, 8) Gates and Rees,(13) and Cleland,(5) in which the spireme in the heterotypic prophase is said to be formed by an irregular process of condensation rather than by the union of two distinct threads.

During the later period of the synezesic contraction the chromatic knot appears very complex and the nature of the spireme is rather difficult to determine. This is the most critical period of the life-cycle of the heterotypic mitosis. The general significance of this contraction, and its relation to the changes that take place during the early heterotypic prophase, has been apparently the cause of many confusing accounts and interpretations by many investigators. The massing of the chromatin material at one side of the nuclear cavity of the mother-cell nucleus previous to the formation of the chromosomes of the first heterotypic mitosis was first observed in 1895 by Moore,(18) and he called it synapsis. Sargant,(22) in 1897, reported that she observed the same condition, not only in fixed material, but also in the living pollen mother cell of *Lilium*. Following the discovery of this phenomenon several eminent cytologists have taken a great interest in the study of synapsis in both animals and plants. Among the prominent students of synapsis may be cited the following: Allen,(1) who believes that the fusion of threads and of the chromosomes occurs very early in synapsis; Farmer and Moore,(10) who noted the long duration of this stage, the development and loosening of the spireme, and the relative increase in size of the nuclear cavity in *Lilium;* Cardiff,(4) who states that in the plants studied by him, gravity determines the position that the mass shall take; and Gates,(12) who has published an account on the hybrid of *Oenothera* and pointed out the great reduction in length and the thickening of the spireme during synezesis.

Mottier(19) made a detailed description of synapsis and contradicted the theory advanced by Cardiff; Miss Fraser (11) observed synapsis in *Humaria*, a fungus; Yamanouchi(26) described the synapsis observed in *Nephrodium*, a fern; Davis(6, 7, 8) explains the phenomenon of synapsis as due to general and slow contraction of the reticulum away from the nuclear membrane, a contraction that carries most of the strands toward the center of the nucleus; Gregoire,(14, 15, 16) whose general interpretation does not differ very much from the others,

although he believes that the pairing of the maternal and paternal elements takes place during this period of the nuclear activity; Lawsons,(17) who made a critical study of this phase of the heterotypic mitosis, believes that—

> . . . during this phase known as synapsis there is no contraction whatever of the chromatin substance, and this contraction stage has nothing whatever to do with the blending or fussion of maternal and paternal chromatin threads and consequently plays no rôle in the process of chromosome reduction.

In his concluding paragraph he states—

> My interpretation of the phenomenon known as synapsis is simply that it represents a growth period of the nucleus—a condition that is in harmony with the peculiar organization of spore-mother-cells. It is a period during which the increasing karyolymph exerts a great osmotic pressure from within. This pressure results in the extension of the nuclear cavity towards an intercellular space where there is least resistance from the neighboring cells. The chromatin mass is left behind, and its characteristic position at one side of the nuclear membrane is a perfectly natural one.

On the other hand, Gates and Rees have shown by means of a series of measurements in the growth period of *Lactuca* pollen mother cells, that in synezesis the reticulum undergoes contraction to approximately half the diameter of the resting nucleus, and that there is a steady growth of the nucleus. Their findings were corroborated by the writer's observations on *Elodea gigantea*,(20, 21) in which careful measurements on the growing period of the pollen mother cells were also made.

Recently Digby,(9) in her extensive work on *Osmunda*, has indicated that during synezesis the association of the chromatin threads derived from the telophasic split of the chromosomes during the last somatic mitosis is consummated. While Gregoire(14, 15, 16) agrees in the doubling of the spireme during the synezesic contraction, yet he believes that the pairing threads are of paternal and maternal origin. Therefore, these views seem to show that it is during the synezesic contraction when the doubling of the spireme takes place, and that this contraction is apparently the process responsible for the bringing together of the threads. In the case of *Cocos nucifera*, however, it seems that neither of the two interpretations can be applied. The early spireme appears to be distinctly single with a slightly unequal thickening in some places, while in some instances a slight parallelism is observed. But these instances are rare in comparison with the cases in which the spireme is found single. The plausible explanation for this, therefore, is the unequal condensation and contraction of the various threads of the system. During

synezesis the delicate univalent threads gradually condense into a relatively short and thick spireme which becomes arranged into as many loops as the bivalent number of chromosomes. From this fact it is evident that in *Cocos nucifera* the chromosomes of the heterotypic mitosis are not formed side by side through the parallel association of two distinct paternal and maternal elements, but are developed from a single spireme, which by segmentation forms thirty-two monovalent chromosomes arranged end to end.

Gates and Rees,(13) in their paper on *Lactuca*, state that—

> The complete loops separate in the segmentation of the spireme. Each bivalent chromosome is thus constituted from the two arms of a loop. This structure condenses greatly, and it appears that in some cases at least the torsion remains. If this account of the formation of the bivalents is true, and we can see no escape from it, the synezesis has no part in bringing about the pairing, and its significance as a unique physiological condition of the nucleus remains entirely obscure.

While the individual loops are gradually separated from each other by process of segmentation, they become short and thick and the free ends do not twist about each other, therefore true "strepsinema" does not occur in *Cocos*. The segments are distinctly single in nature and no sign of fission or splitting can be noticed. As the process of condensation proceeds the spireme passes into a second contraction, the greater portion of the spireme filaments become collected and entangled at one side of the nucleolus.

In the diakinesis stage of *Oenothera franciscana*, Cleland(5) observed the constant and uniform linking together of bivalent chromosomes which, according to him, is—

> . . . a penomenon which can hardly be explained on a parasynaptic basis; and, the most reasonable explanation seems to be that the bivalent chromosomes represent sections of the spireme which occupied such a position in the nucleus that, when the whole system became condensed, the chromosomes found themselves linked in this very definite way.

In the diakinesis of the mother cells of *Cocos nucifera* a more or less similar linking of the chromosomes is observed; this is strong evidence for the end to end arrangement, or telosynaptic interpretation.

SUMMARY

The chromatin reticulum in the resting stage of the pollen mother nucleus of *Cocos nucifera* Linnæus is granular in character and is evenly distributed in the nuclear cavity.

In the early heterotypic prophase the chromatin threads are arranged in a very irregular manner and in them there is a very slight parallelism.

The synezesis is brought about by the contraction of the reticulum, accompanied by a rapid growth of the nucleus. The spireme is formed by an irregular condensation of the chromatin threads and appears at this stage single and unsplit.

Following the long period of synezesic contraction the univalent unsplit spireme gradually spreads throughout the nuclear vacuole and forms loops equal to the gametic number of the chromosomes.

Soon after the spreading of the spireme it passes into a second contraction, and this process is followed by the gradual separation of the loops from one another by segmentation.

Each loop consists of two monovalent chromosomes arranged end to end.

While the segments emerge from the second contraction they undergo considerable condensation and become shorter and thicker.

The thickened segments at the early diakinesis stage appear like J's, O's, X's, Y's, and U's, while in the later stages some of them simulate dumb-bell-shaped bodies, and still others, straight and bent rods.

There are sixteen bivalent chromosomes, and in some instances, due to overlapping, there are fifteen. One of the chromosomes is strikingly larger than the others, while three of the chromosomes are smaller.

The multipolar spindle appears after the dissolution of the nuclear membrane and nucleolus.

At the metaphase stage the bivalent chromosomes are arranged more or less evenly and symmetrically in one plane.

All the sixteen bivalent chromosomes split lengthwise at the same time, and as the daughter chromosomes move toward the two poles they take on the V- or the J-shape, with apex toward the poles.

The splitting, or fission, is observed only at the late telophase stage during the formation of the nuclear membranes of the daughter nuclei.

The daughter nuclei resulting from the first division do not pass into anything resembling a typical resting condition. They soon reorganize and prepare for the homœotypic division.

As the nuclear membranes and the nucleoli of the daughter nuclei disappear, the two homœotypic spindles make their ap-

pearance simultaneously. The univalent chromosomes proceed to the two equatorial plates and split lengthwise equally to form the four granddaughter nuclei.

I wish to express my appreciation and gratitude to Miss Maria D. Pastrana for some of the material used, and to Mr. Demetrio Andres, who assisted me in the collection of the material from San Pablo, Laguna.

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ILLUSTRATIONS

[All figures were drawn with the aid of a camera lucida under the Spencer 1.5 mm. N. A. I. 1.30 apochromatic objective in combination with Carl Zeiss K 20 ocular and Carl Zeiss Orthoskop-Ockular 28x, giving a magnification of 4,100 and 5,500 diameters, respectively. The drawing were reduced to two-thirds in the reproduction.]

PLATE 1. COCOS NUCIFERA LINNÆUS

FIG. 1. A resting nucleus in pollen mother cell, showing a single large nucleolus and the uniformly distributed delicate threads with nodelike chromatic thickening. × 2733.

2. A pollen mother-cell nucleus entering into early prophase; note the irregular thickening of the threads in the reticulum. × 2733.

3. A definite stage of the heterotypic prophase. The reticulum is more defined, consisting of fine threads with irregular thickening and nodelike chromatic granules at the junction of the meshes. × 2733.

4. The beginning of the synezesic contraction and early stage of the spireme; note its irregular thickening. × 2733.

5. A portion of a superficial section of a nucleus entering into synezesic contraction in the same stage as fig. 4. × 3666.

6. A more-definite stage of early synezesis, showing the gradual withdrawal of the early spireme from the nuclear membrane. × 2733.

7. A superficial section of a nucleus in the same stage as fig. 6, showing the unsplit and univalent character of the spireme. × 3666.

8. An early stage of synezesis. The unilateral massing of the chromatin threads is more conspicuous and the meshes are greatly reduced in size. × 2733.

PLATE 2. COCOS NUCIFERA LINNÆUS

FIG. 9. A more-advanced synezesic contraction; the threads and the meshes are drawn into a close mass. A portion of the spireme is extending across the nuclear cavity to the nuclear membrane. × 2733.

10. The appearance of the spireme at the complete synezesic contraction. × 2733.

11. A thin tangential view of the synezesic knot in the same stage as fig. 10, showing the hazy outline and the spiral twisting of the spireme. × 3666.

12. The univalent spireme emerging from the synezesic knot; note the delicate fibers connecting the loops to the nuclear membrane. × 2733.

13. The loosening of the spireme from the synezesic knot and the formation of loops is well underway. The spireme appears more distinct and uniform in character. ×2733.
14. A segment of a superficial section in the same stage as fig. 13. × 3666.
15. An early stage of the hollow spireme; note the loops extending toward the periphery of the nuclear cavity and the well-defined and more-uniform outline of the spireme. × 2733.

PLATE 3. COCOS NUCIFERA LINNÆUS

FIG. 16. A complete hollow spireme. × 2733.
17. A later stage of the hollow spireme; the loops are shortening and the sides of each loop are brought close together while the segmentation begins to take place. × 2733.
18. Slightly older stage than the one shown in fig. 17. The approximation of the sides of each loop and the segmentation are more evident. × 2733.
19. Early stage of the second contraction. × 2733.
20. A complete second contraction. × 2733.
21. The bivalent segments coming out from the second contraction, which are greatly thickened and shortened. × 2733.

PLATE 4. COCOS NUCIFERA LINNÆUS

FIG. 22. The bivalent segments after the second contraction. × 2733.
23. Early diakinesis stage. The bivalent segments are under the process of condensation and assume different configurations. × 2733.

FIGS. 24 and 25. Slightly older, two similar stages, showing the U-, Y-, J-, O-, and V-shaped chromosomes. × 2733.
26*a* and 26*b*. The two halves of the pollen mother-cell nucleus with sixteen bivalent young chromosomes. × 2733.

PLATE 5. COCOS NUCIFERA LINNÆUS

FIG. 27. A tangential section of the nucleus, a slightly older stage than fig. 26, showing the X-, O-, Y-, and V-shaped chromosomes. × 2733.
28. Three bivalent segments in the same stage as fig. 27 under higher magnification. × 3666.
29. A tangential section of the nucleus showing the appearance of the bivalent chromosomes after a greater condensation; shortening and thickening have taken place. × 2733.

FIGS. 30 and 31. Two diakinetic stages, one closely following the other. The bivalent chromosomes appear as dumb-bell-shaped and as straight and bent rods. × 2733.
32 and 33. Another two successive stages of the late diakinesis, showing the formation of the multipolar spindle fibers. × 2733.

FIG. 34. Spindle fibers becoming bipolars and the bivalent chromosomes are moving toward the equatorial region. × 2733.

PLATE 6. COCOS NUCIFERA LINNÆUS

FIG. 35. A polar view showing the sixteen bivalent chromosomes at the equatorial plate. × 3666.

36. Side view of the metaphase of the first division. × 3666.
37. Typical side view of anaphase in which the daughter chromosomes are mostly V- and J-shaped with apex of V and J attached to the spindle. × 3666.
38. Early telophase of the heterotypic mitosis. × 3666.
39. A somewhat oblique polar view of the same stage as fig. 38. The daughter chromosomes are mostly V-shaped. × 3666.
40. A typical heterotypic telophase, showing the elongation of the daughter chromosomes, their splitting, and the formation of the clear spaces between them. × 3666.
41. A later stage of one of the daughter nuclei in the heterotypic telophase after the appearance of the nuclear membrane. × 3666.

PLATE 7. COCOS NUCIFERA LINNÆUS

FIGS. 42 and 43. Two stages of one of the daughter nuclei, indicating the very irregular shape of the daughter chromosomes apparently going to resolve, but remaining more or less in this condition for a short period and not passing to true resting stage. × 3666.

FIG. 44. A polar view of the daughter chromosomes at the metaphase stage of the homotypic mitosis. × 2733.

FIGS. 45 and 46. Two views of homotypic metaphases. × 2733.

FIG. 47. A homotypic telophase, showing the side view of the future granddaughter nuclei. × 2733.

48. A granddaughter nucleus after the appearance of the nuclear membrane and the nucleolus. × 3666.

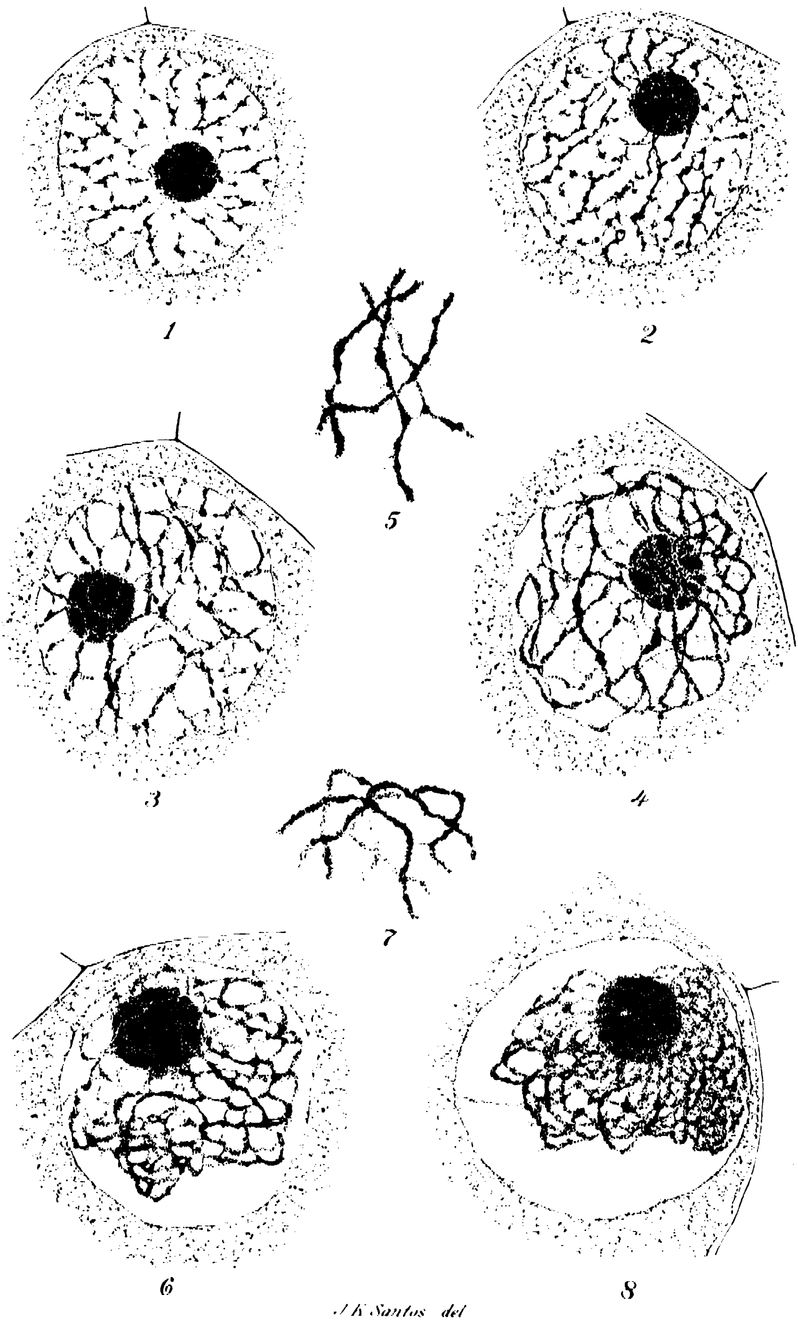
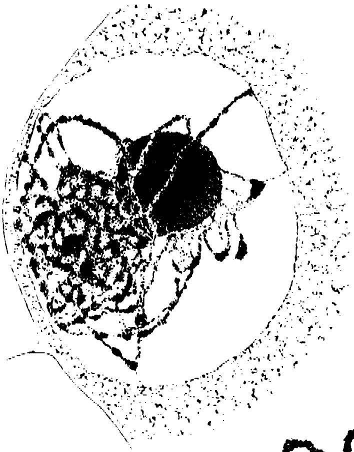


PLATE 1.



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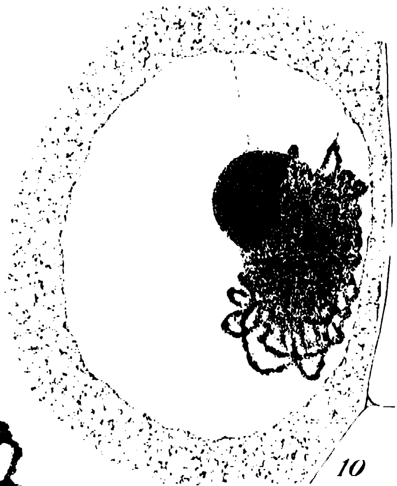

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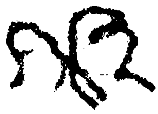

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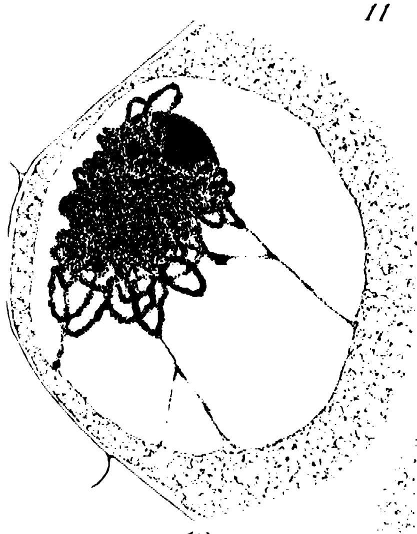

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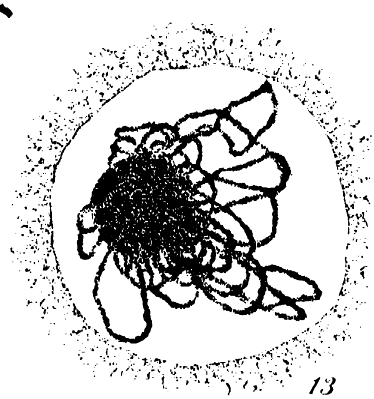

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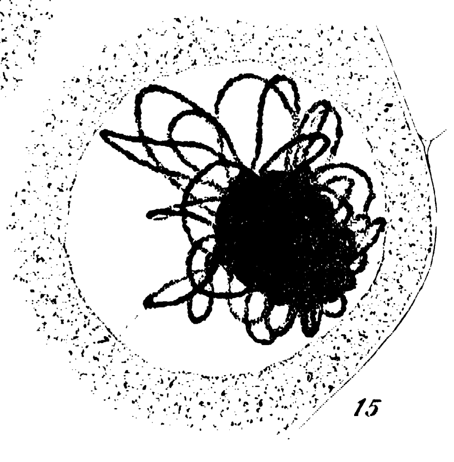

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PLATE 2.

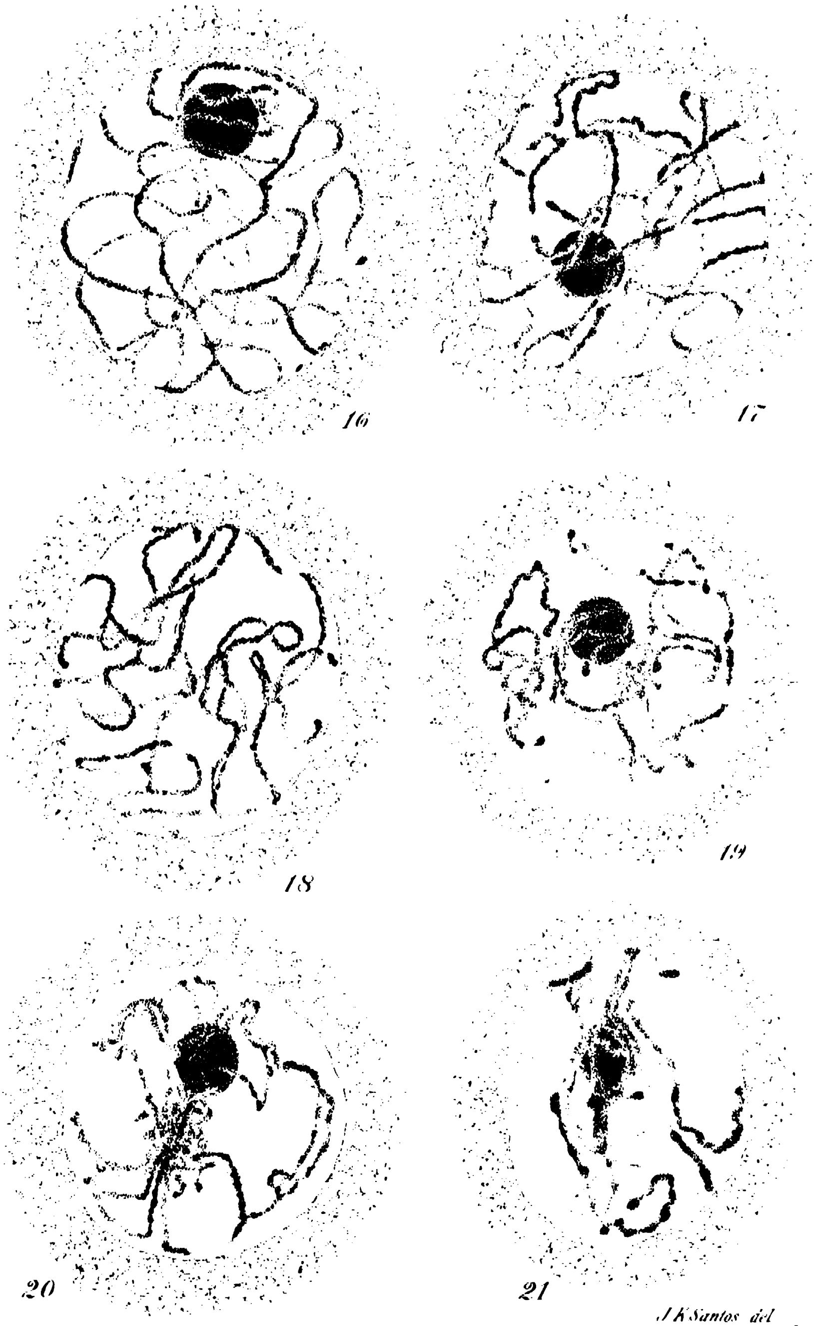

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PLATE 3.

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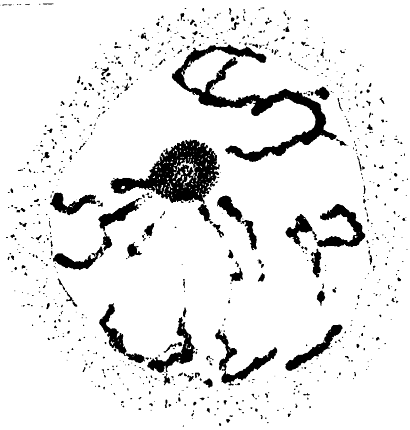

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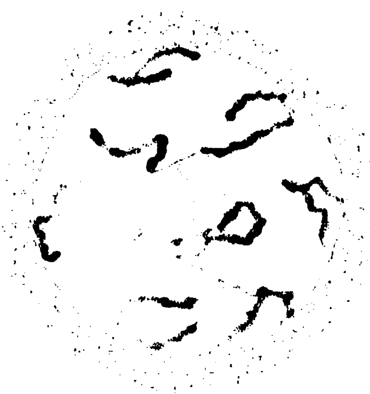

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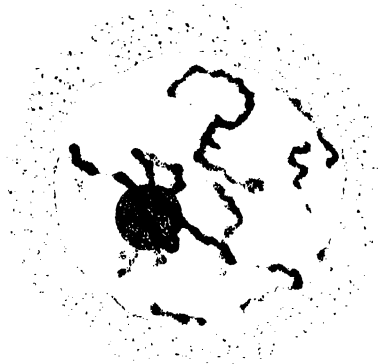

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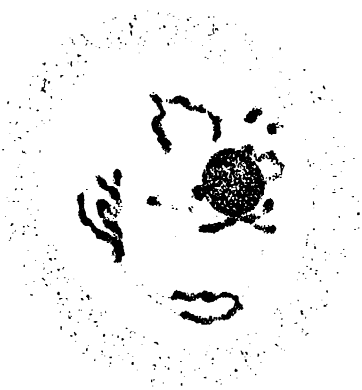

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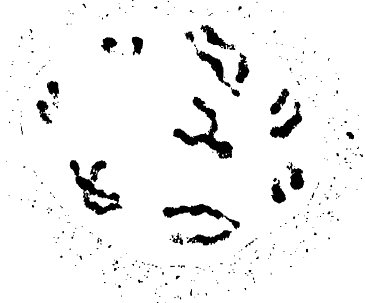

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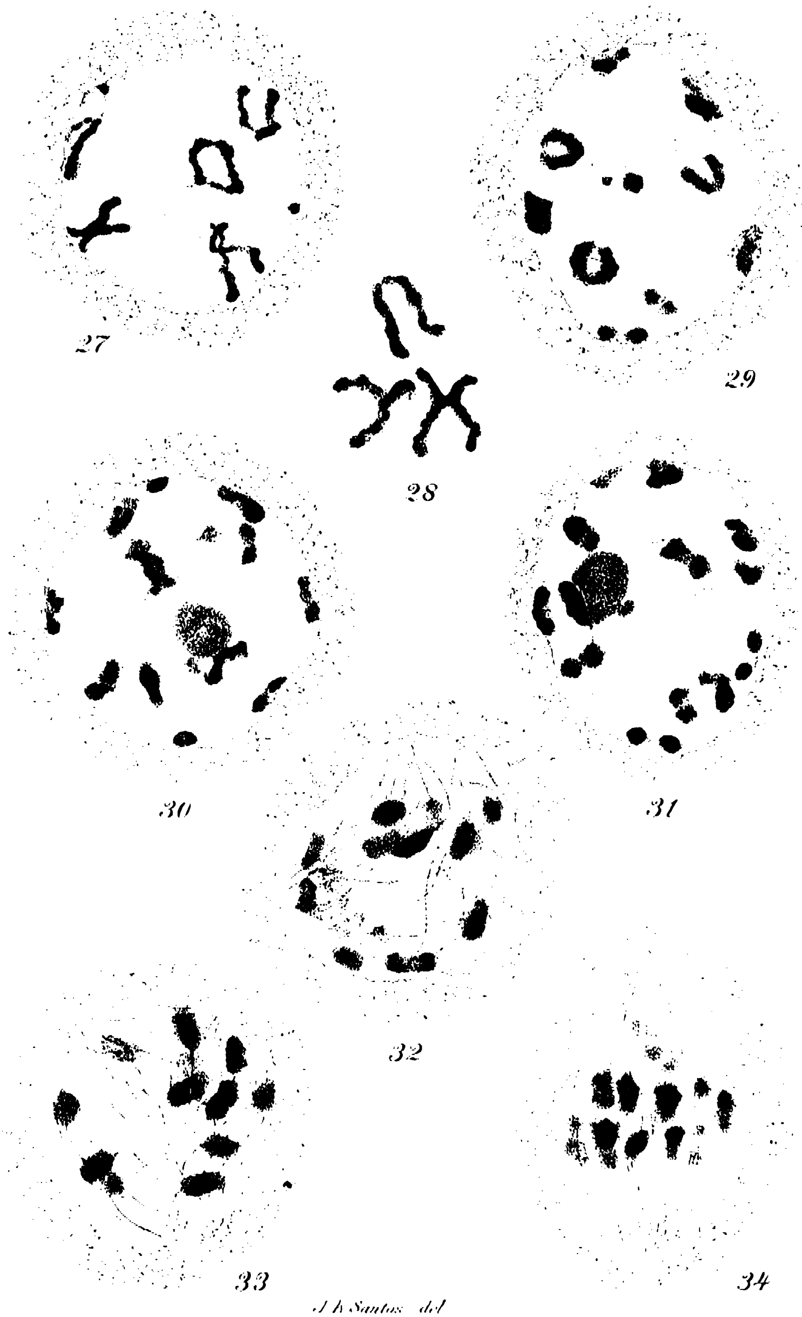
PLATE 4.



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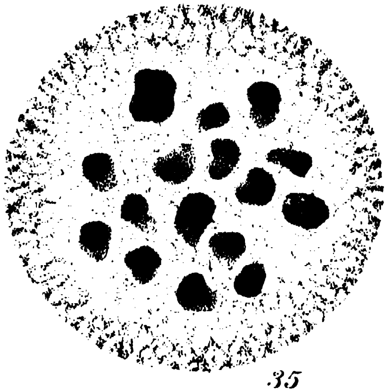

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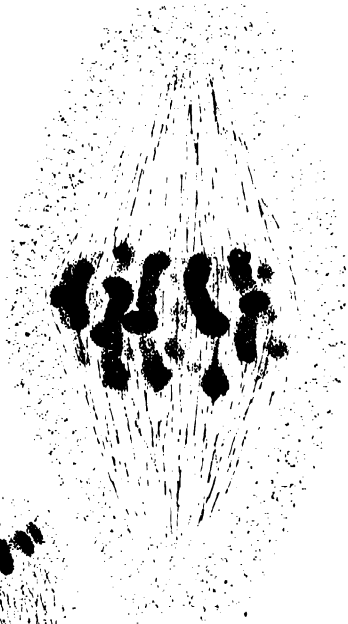

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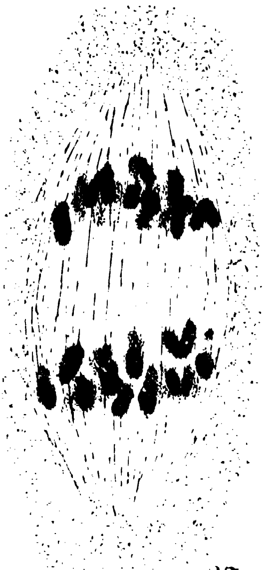

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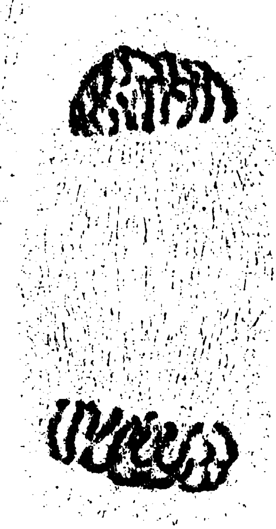

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PLATE 6.

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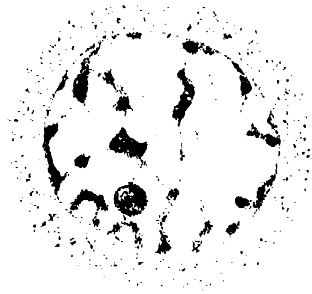

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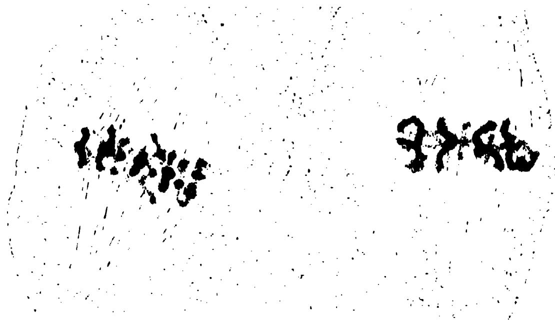

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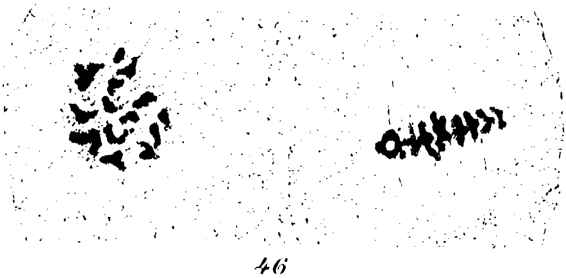

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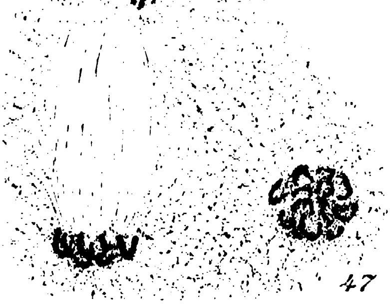

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PLATE 7.

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[New names and new combinations are printed in **boldface**.]

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